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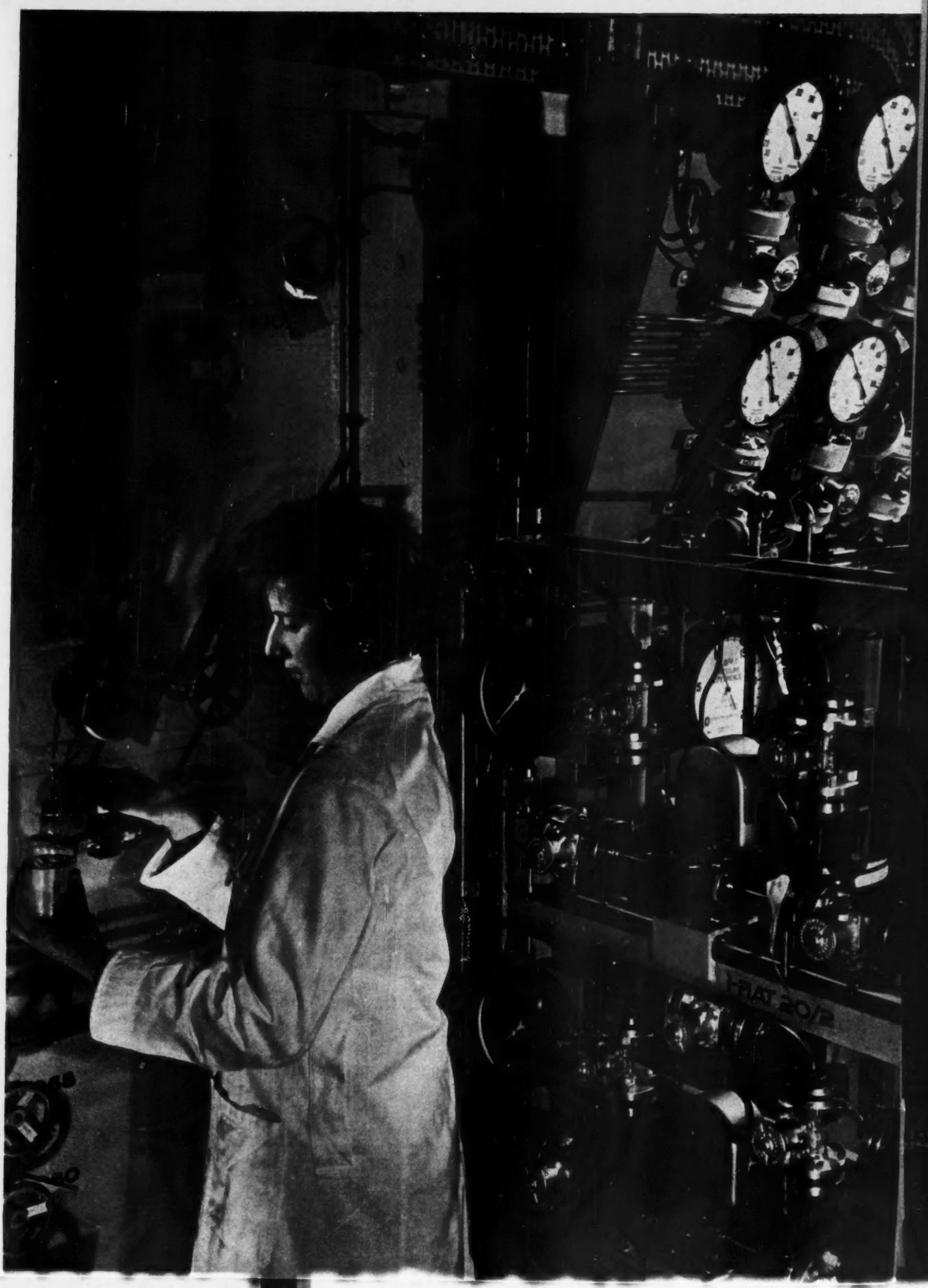

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Sampling Heavy Water

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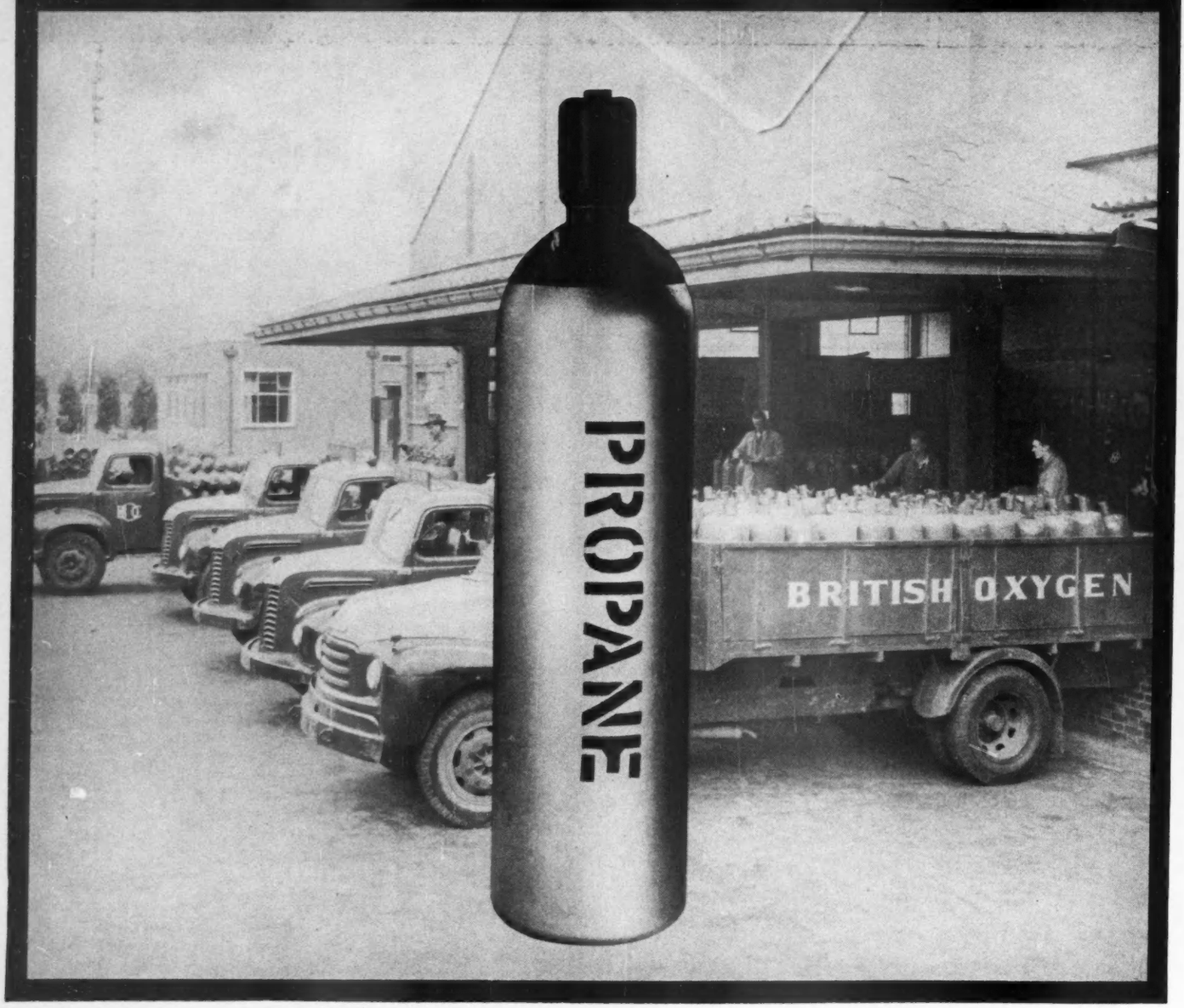

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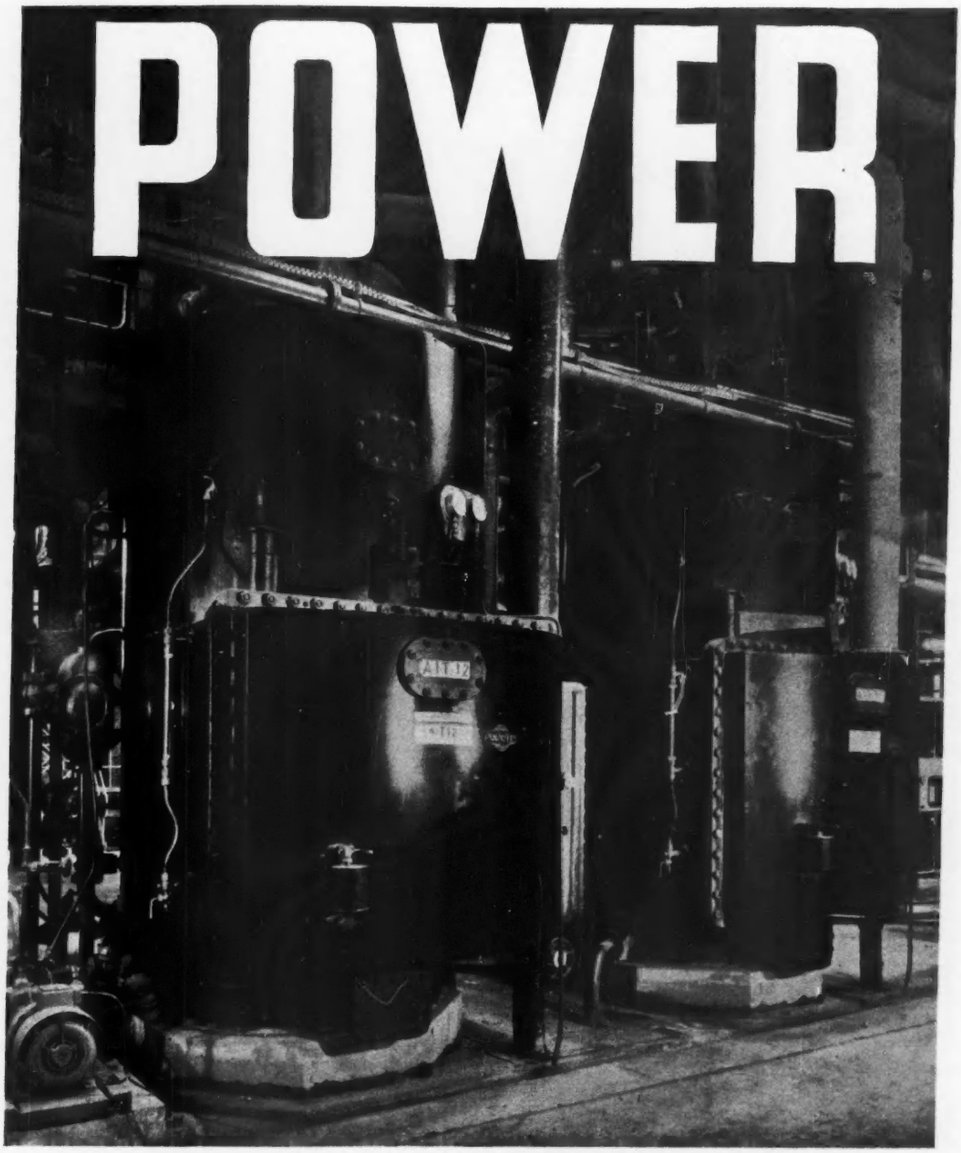

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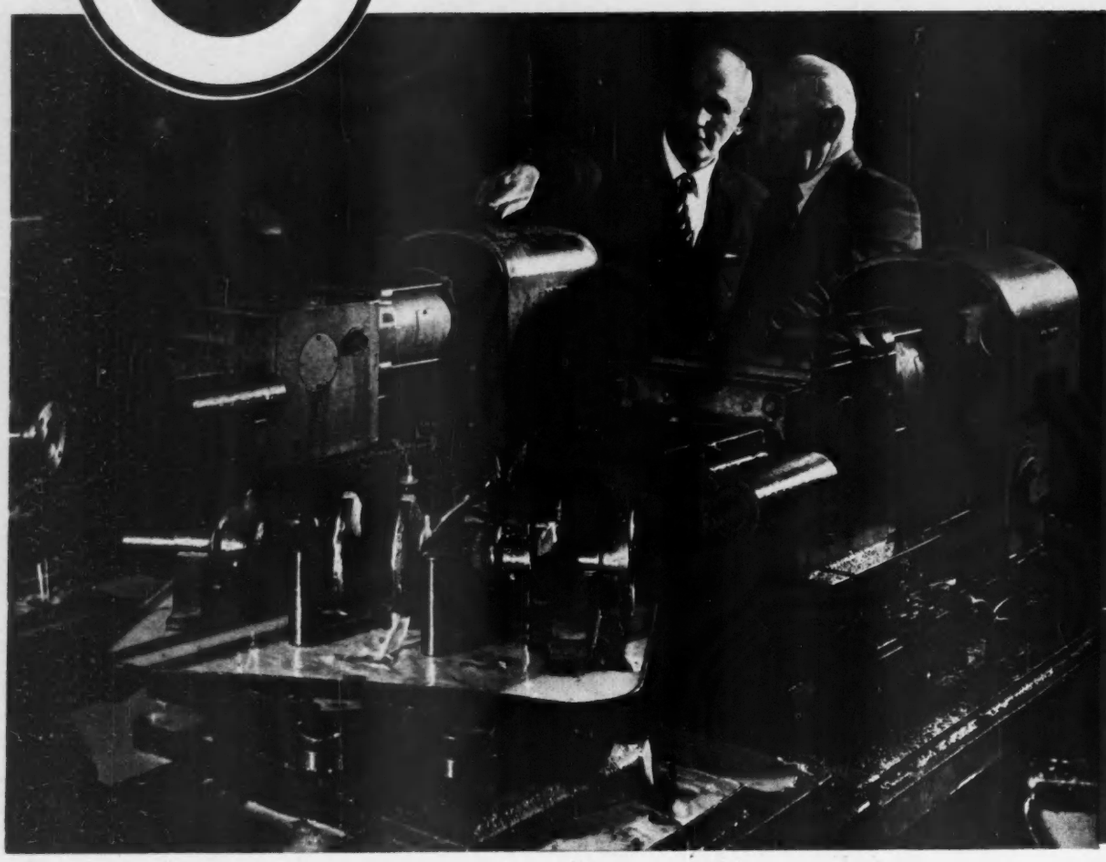

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5 special features make Regent Regal (R & O) Oils invaluable for all hydraulic operations

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To operate efficiently, even the simplest hydraulic system must be kept absolutely clean. This means that wear must be reduced, rust eliminated and gum and sludge deposits prevented.
Regal Oils (R & O) do all this, and give long-lasting protection to all industrial hydraulic systems.
Which is why more and more British industries are turning to Regal Oils (R & O) for high quality performance and complete dependability.

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Regal Oils (R & O) contain powerful oxidation inhibitors which minimise the possibility of gum or sludge deposits and increase intervals between drain periods.

PREVENT RUST
Regal Oil (R & O) contain a rust inhibitor which 'plates out' on metal surfaces, forming a tenacious film that is impervious to rusting action of moisture and water. This eliminates the damage so often caused by rust.

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Regal Oils (R & O) are processed so that they are highly resistant to foaming. This characteristic is improved by additive treatment.

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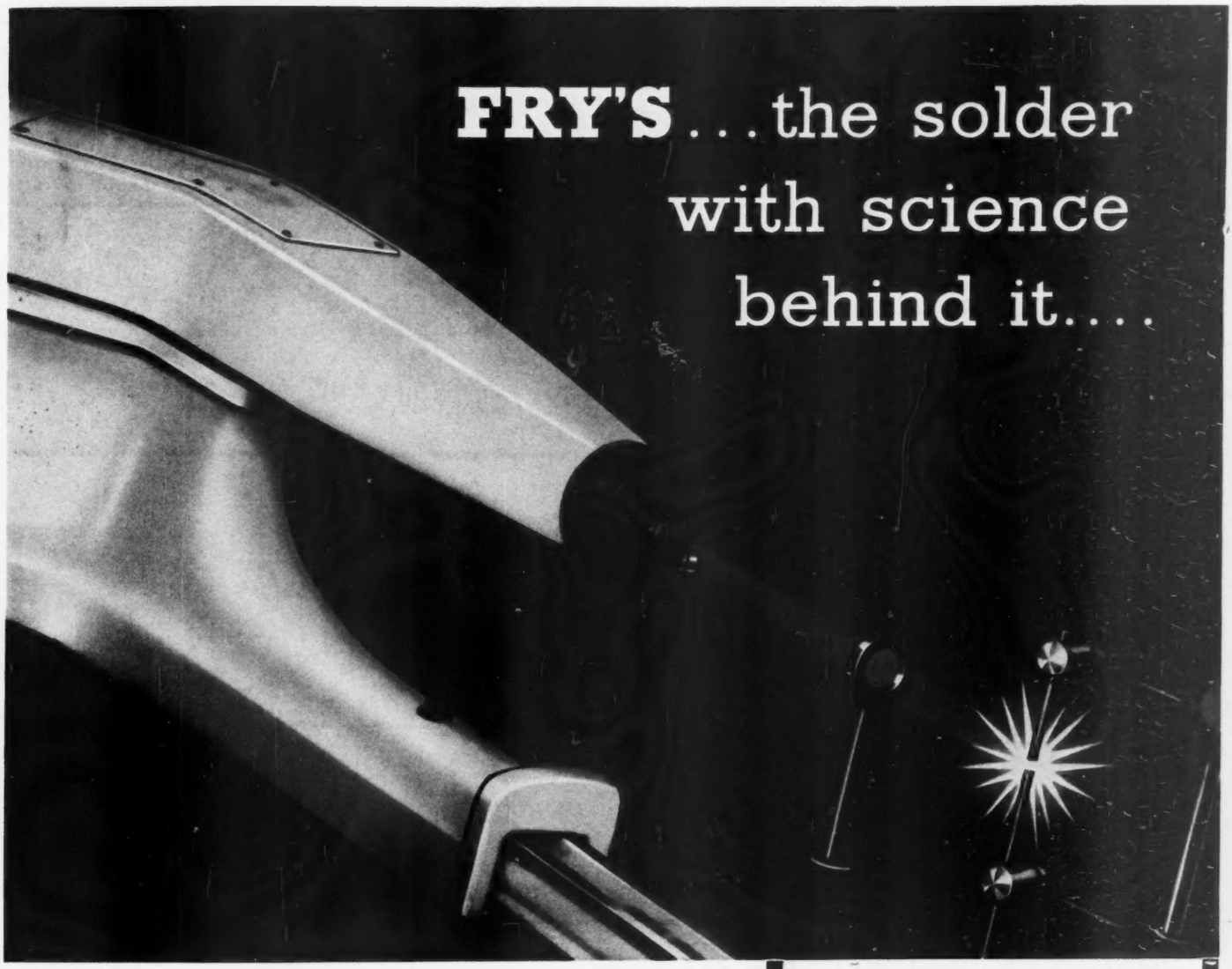

This is a routine spectographic test carried out on every batch of FRY'S solder which leaves the works.

The spectographic test detects harmful impurities which could mean gritty solders causing weak or brittle joints.

This is one of the many ways FRY'S ensure that nothing but pure solders with their characteristic smooth fast bonding reach you.

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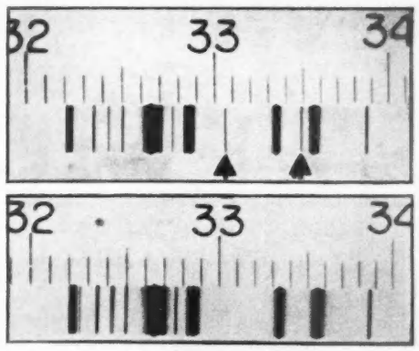

In the top print the fine lines (arrowed) show zinc impurities which mar performance. The print below is free from contaminating impurities-typifying FRY'S solders.

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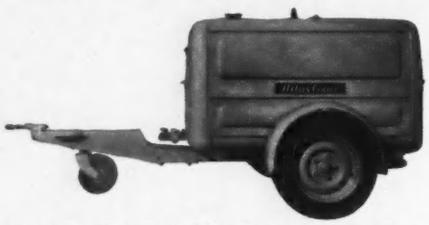
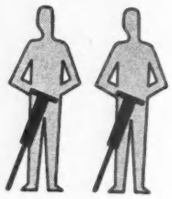
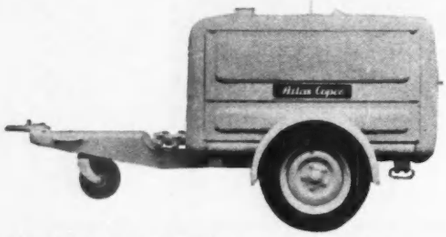
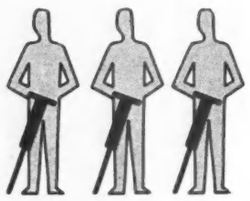




Weight 2,180 lb (990 kg) ★ 115 c.f.m. 3.2m³/m

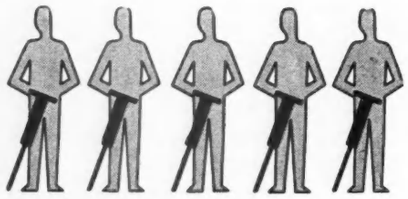
VT4





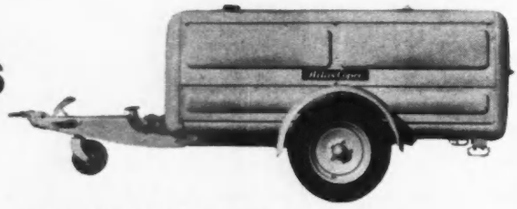
Weight 2,310 lb (1,050 kg) ★ 160 c.f.m. 4.5m³/m

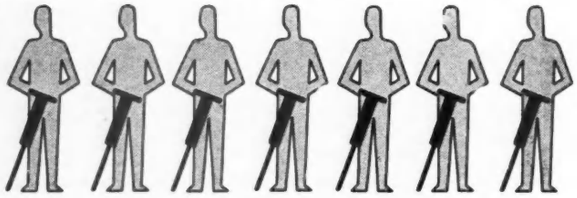
VT5



Weight 2,900 lb (1,315 kg) ★ 225 c.f.m. 6.4m³/m

VT6





Weight 3,590 lb (1,630 kg) ★ 315 c.f.m. 8.9m³/m

No other compressors pack so much power for their size and weight

Atlas Copco now make a full range of VT compressors incorporating the major changes in design and production that have made the VT4 so successful. The VT series consists of four compressors of the same simple basic design, with capacities ranging from 115 to 315 c.f.m. Most of the components for compressors and engines are interchangeable throughout the series, so servicing problems are reduced to a minimum.

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6 May 1960

Vol. 189 No. 4907

Founded in 1866

ENGINEERING

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Cover Picture

A member of the industrial chemistry group at Harwell drawing off a sample of heavy water for analysis. (*Nurnberg photograph for* ENGINEERING.)

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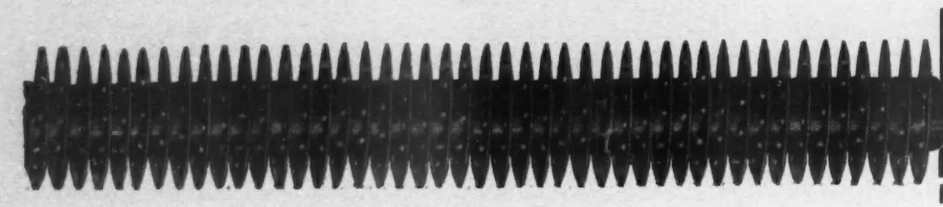

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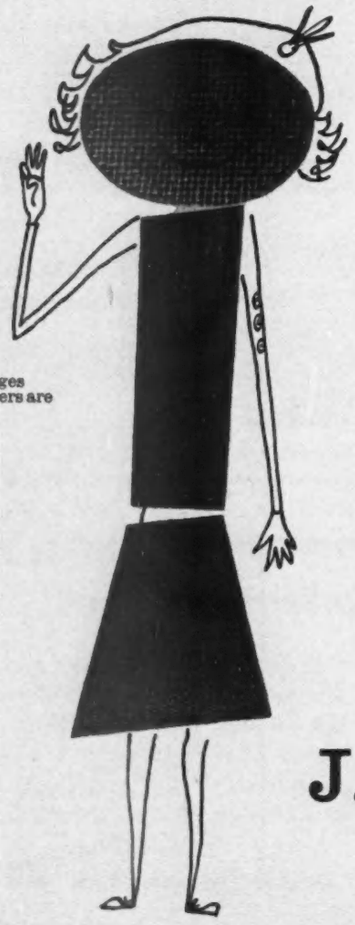

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TENDERS for the following:—

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Specification, etc., can be obtained from the Coordination Branch, India Store Department, Bromyard Avenue, Acton, W.3, at a cost of 10 shillings per tender. The Tenders are due to be returned to India Store Department, at the above address, so as to reach them by 2 p.m. on Thursday, 9th June, 1960.

Specimen copy of the above specification can be seen at ENGINEERING BRANCH, INDIA STORE DEPARTMENT, ACTON, W.3, under the following reference: 2061/59/ENG.2. B 948

KERALA STATE ELECTRICITY BOARD
CIVIL BRANCH
TENDER NO. HEP4/60—
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The last day for receipt of the above tender due on 18th April, 1960, is hereby extended to 3 p.m. on 10th May, 1960. B 947

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3—27 ft. 6 in. by 8 ft. diam. ... 8,500 gallons.
2—25 ft. by 7 ft. 6 in. diam. ... 6,500 gallons.
1—30 ft. by 9 ft. 10in. diam. ... 14,000 gallons.
2—17 ft. by 5 ft. 6 in. diam. ... 1,750 gallons.
5—15 ft. by 4 ft. 3/5 in. diam. 1,250/1,500 gallons.
19—15 ft. by 8 ft. diam ... 4,000 gallons.

RIVETED, DISH-END

1—30 ft. by 8 ft. diam. ... 9,500 gallons.
1—22 ft. by 7 ft. 6 in. diam. ... 6,050 gallons.

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3—30 ft. by 8 ft. diam. ... 9,500 gallons.
1—30 ft. by 7 ft. 6 in. diam. ... 8,000 gallons.
1—24 ft. by 7 ft. 6 in. diam. ... 6,600 gallons.

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1—28 ft. by 10 ft. by 9 ft. deep 15,750 gallons.
1—15 ft. by 6 ft. by 5 ft. 3 in. deep 2,500 gallons.
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2—Riveted D.E., 27 ft. by 6 ft. diam. 365 lb. w.p.
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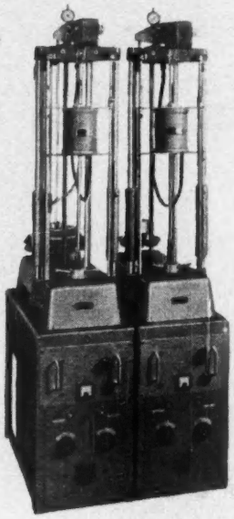

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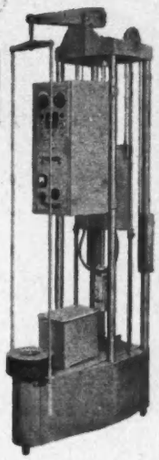

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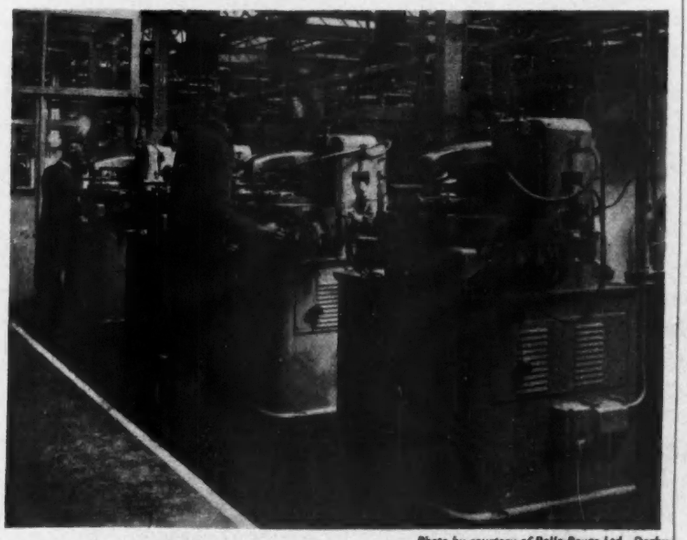

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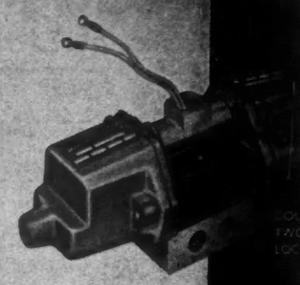

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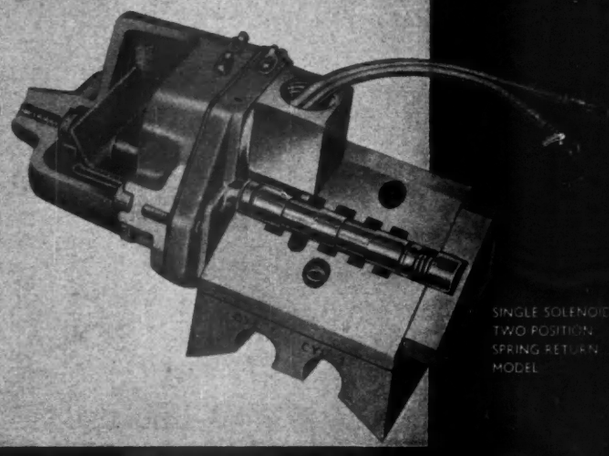

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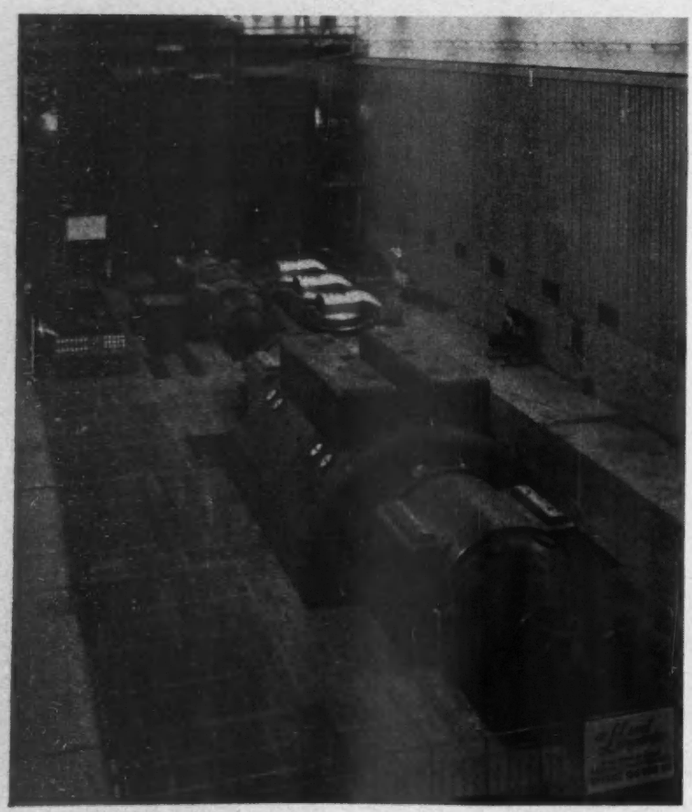

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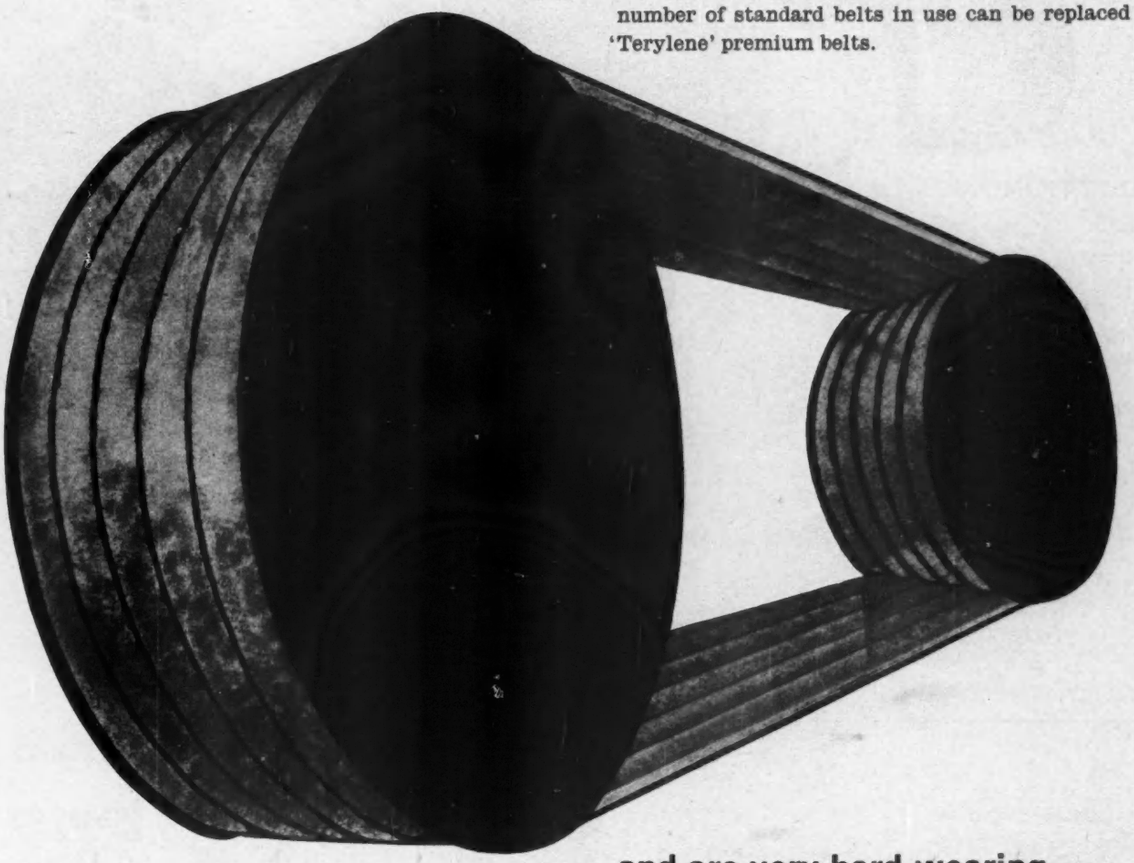

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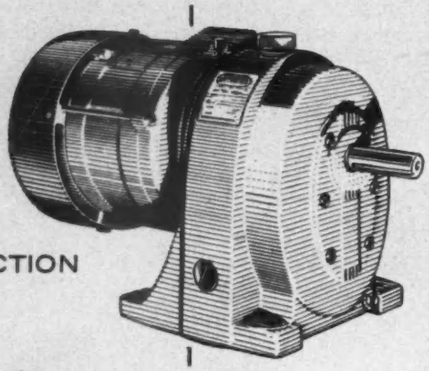

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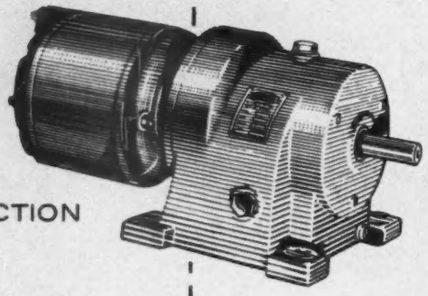

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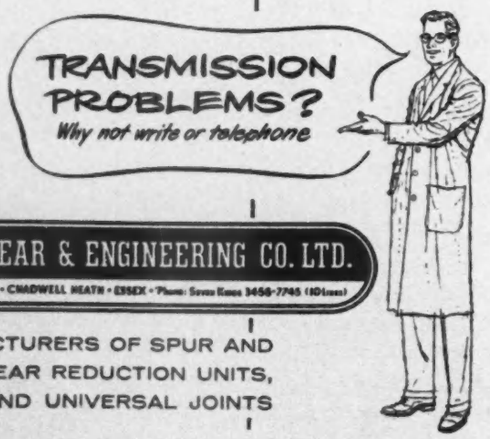

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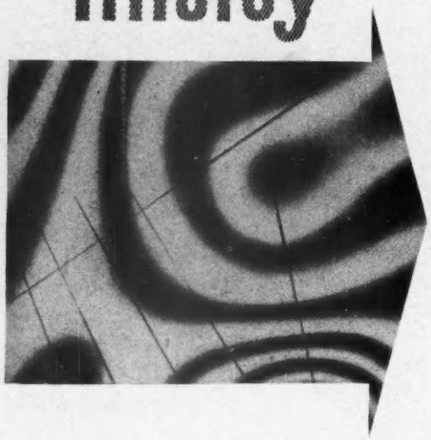

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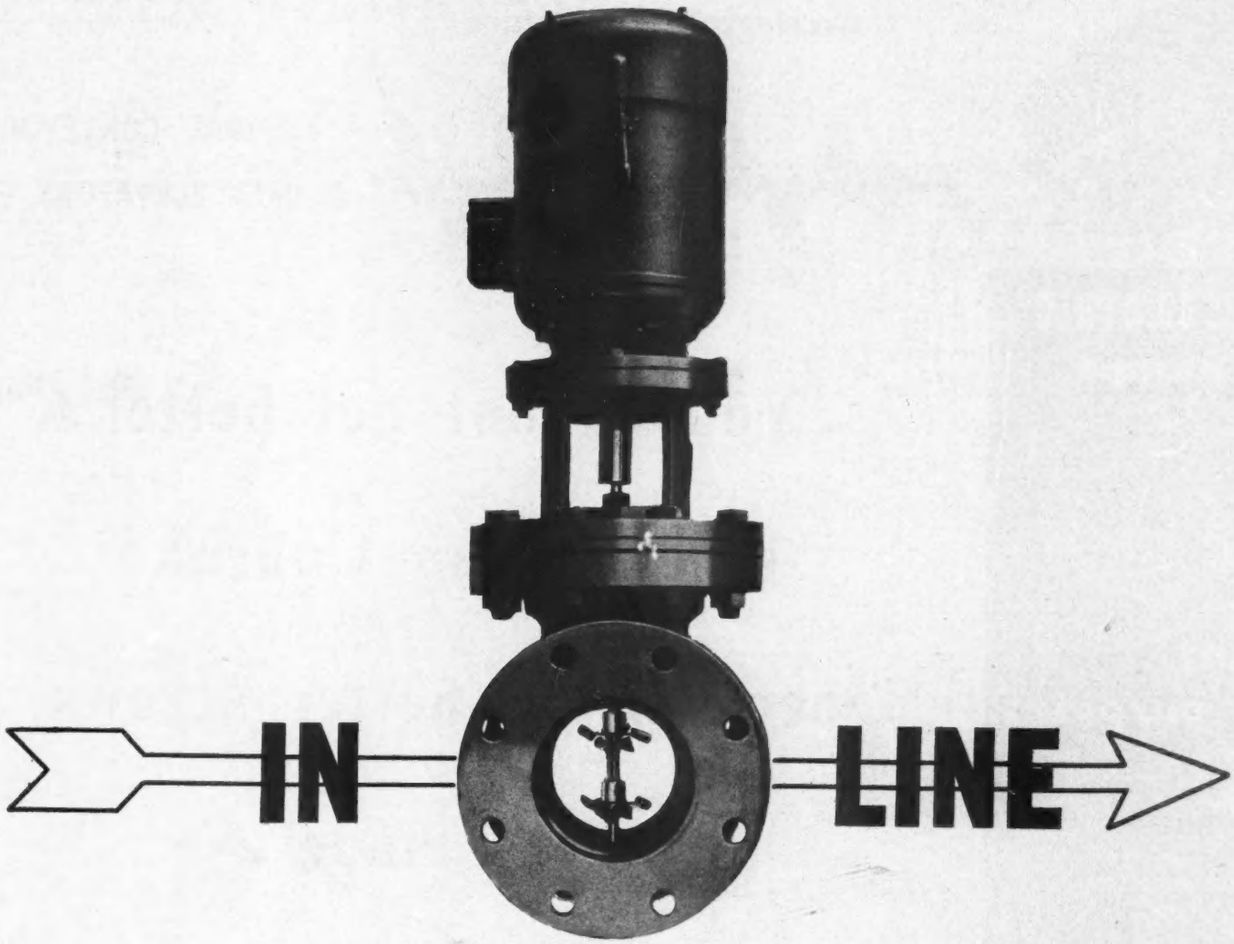

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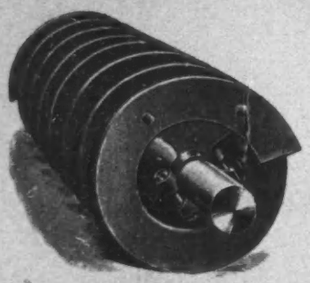

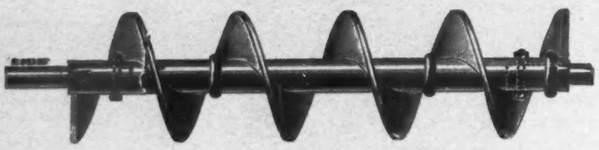

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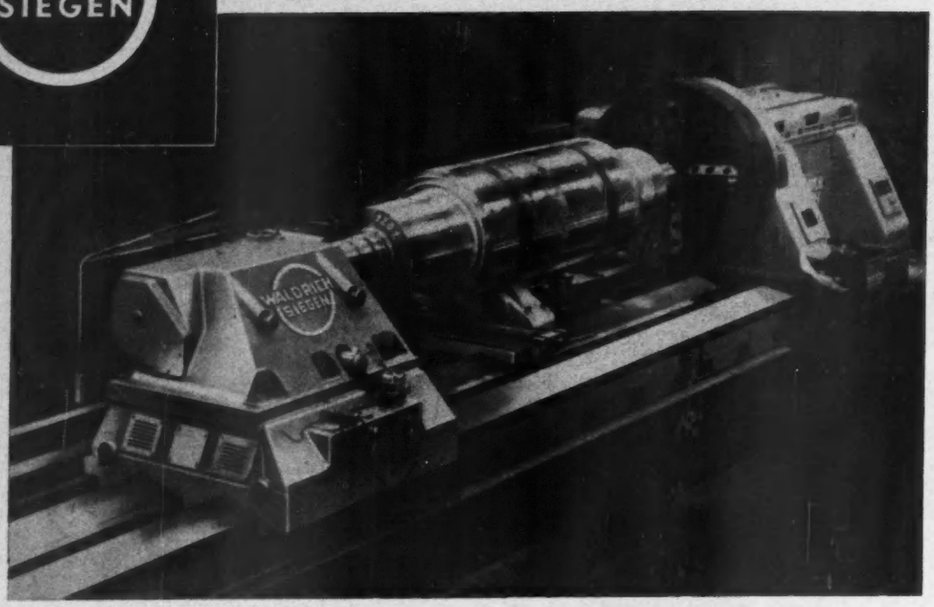

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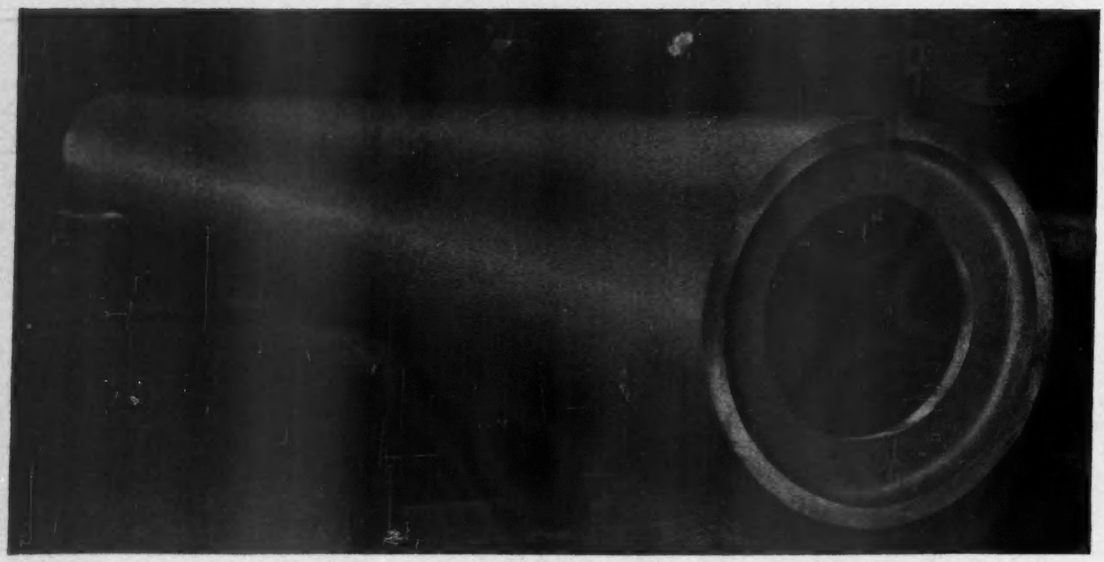

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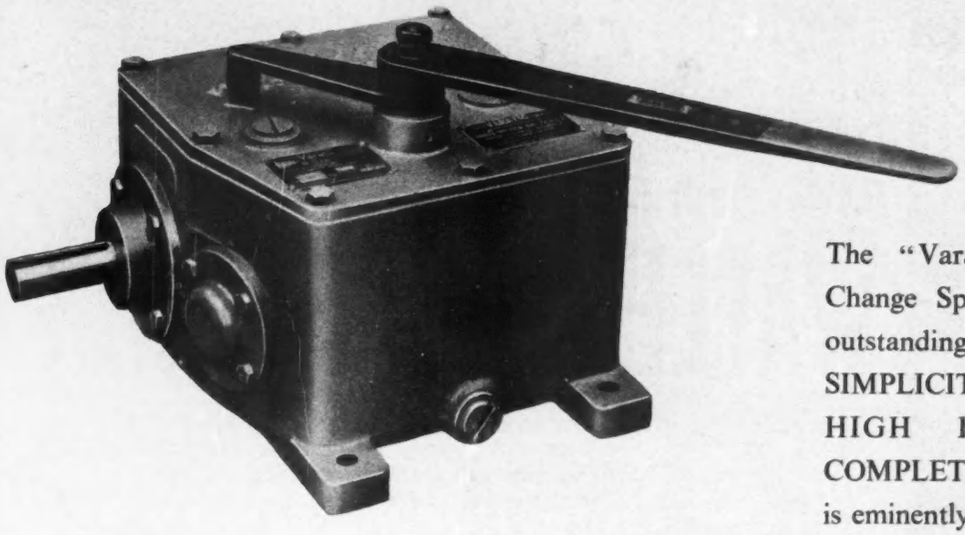

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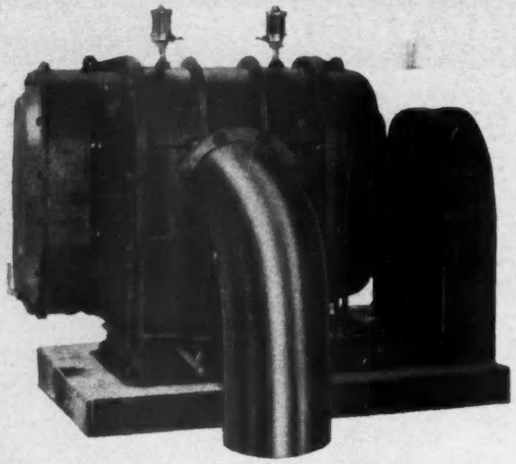

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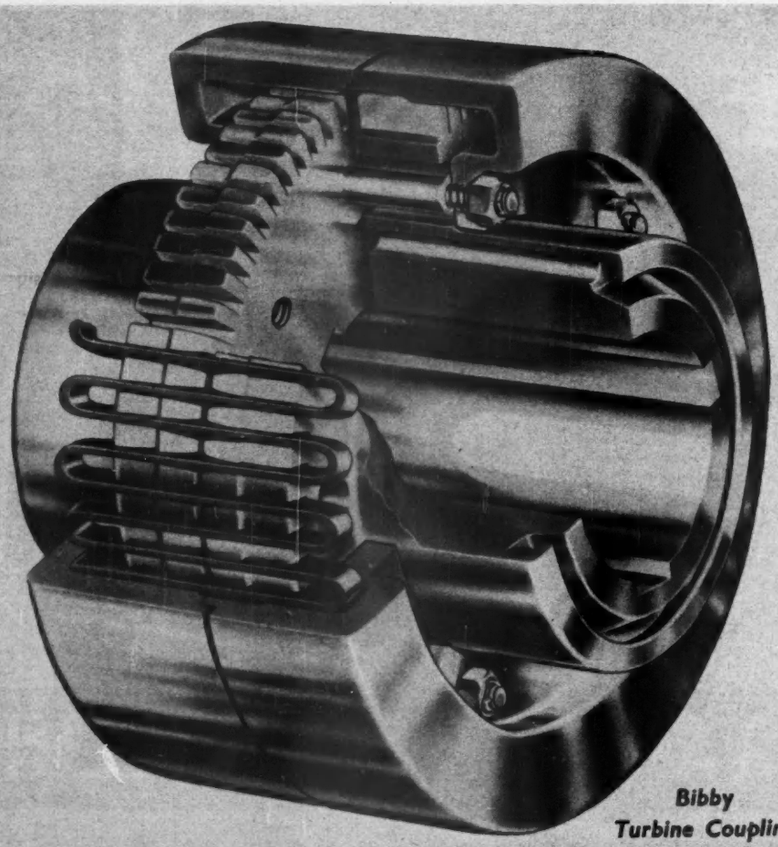

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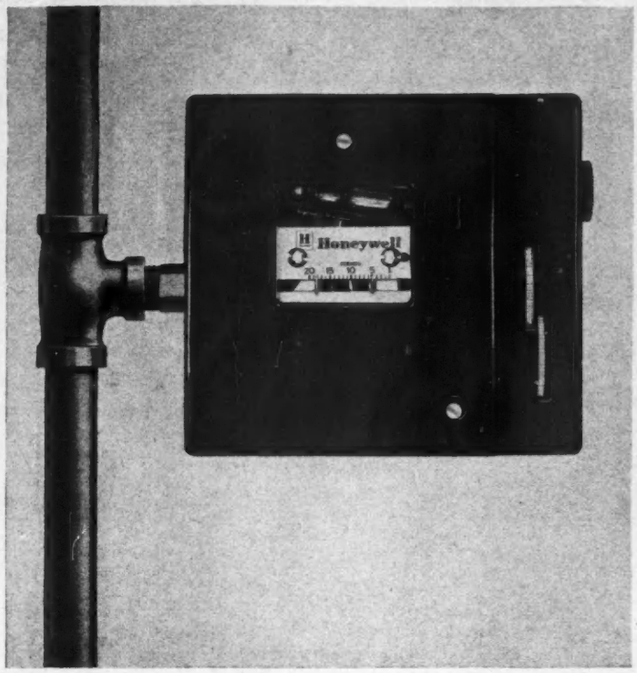
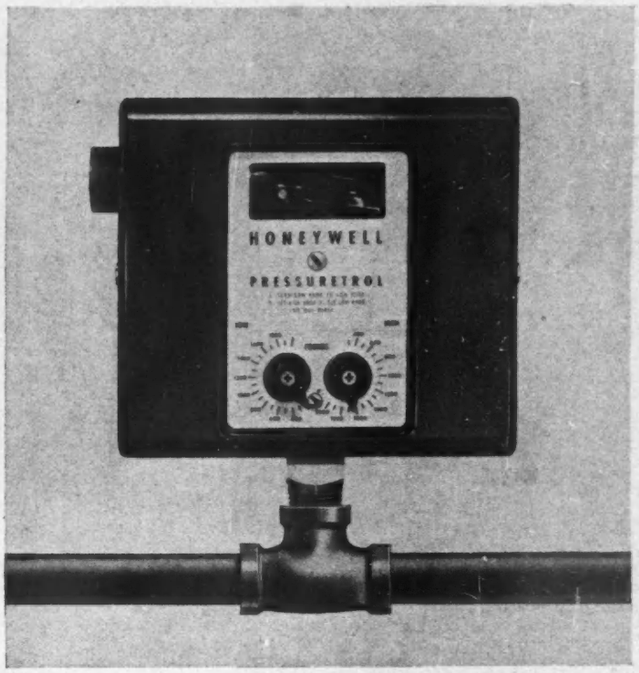


P444



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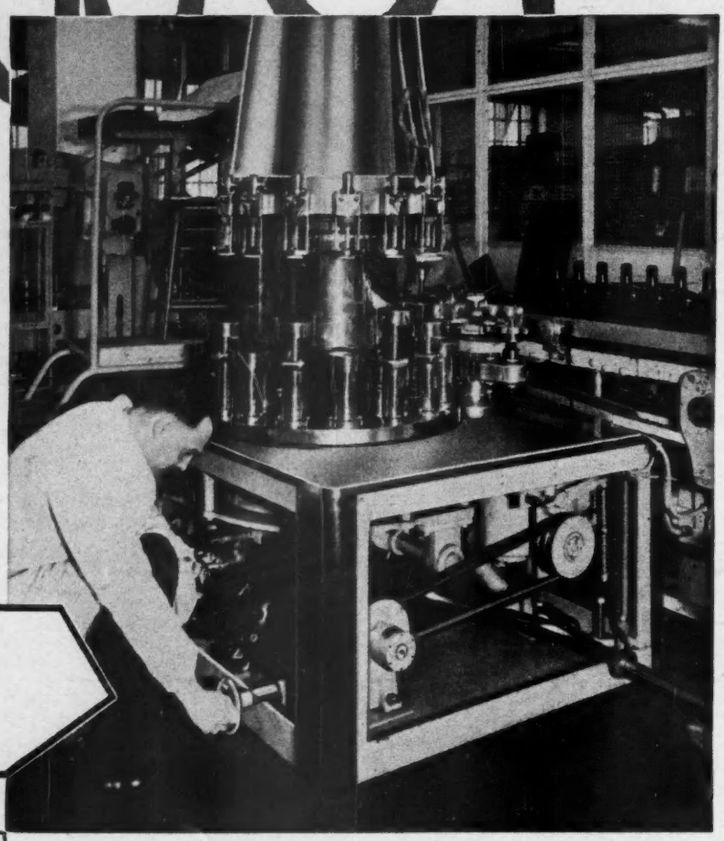

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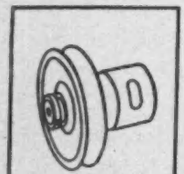

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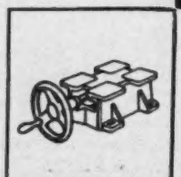

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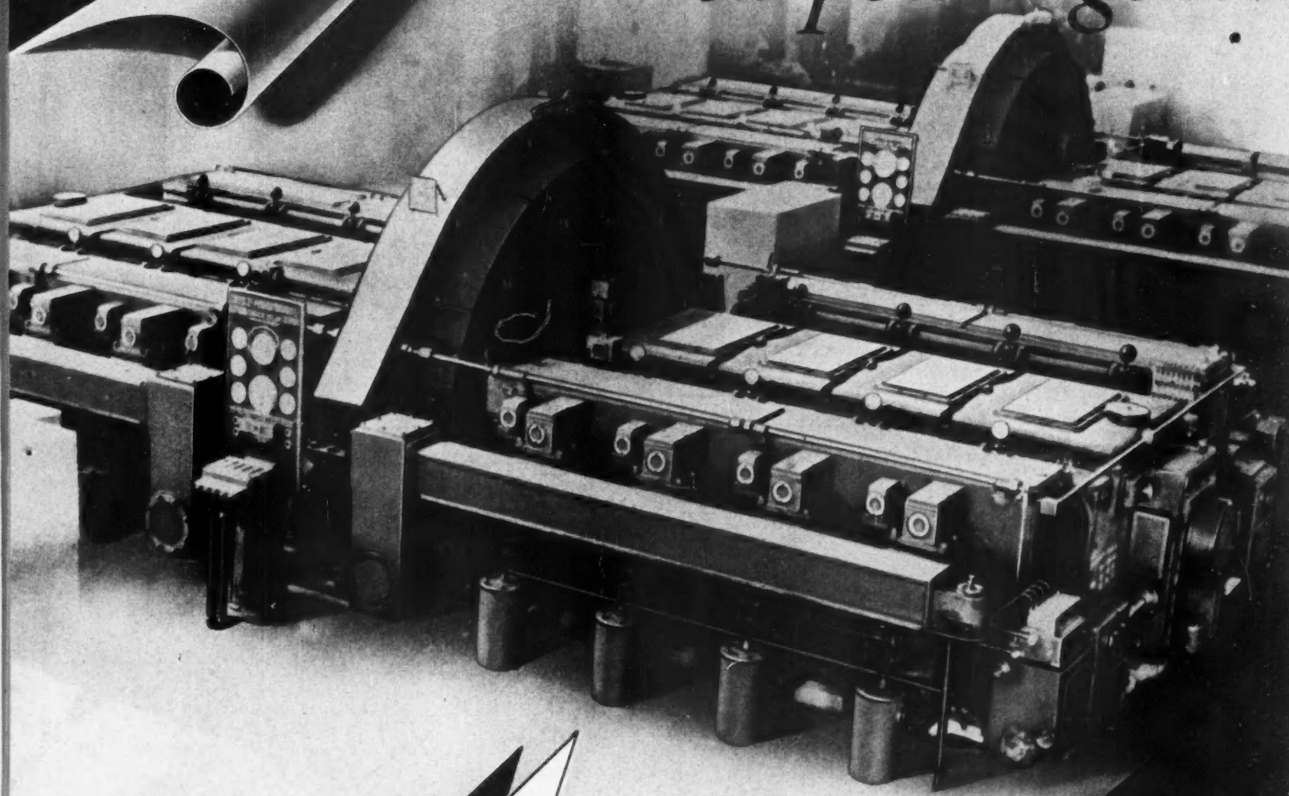

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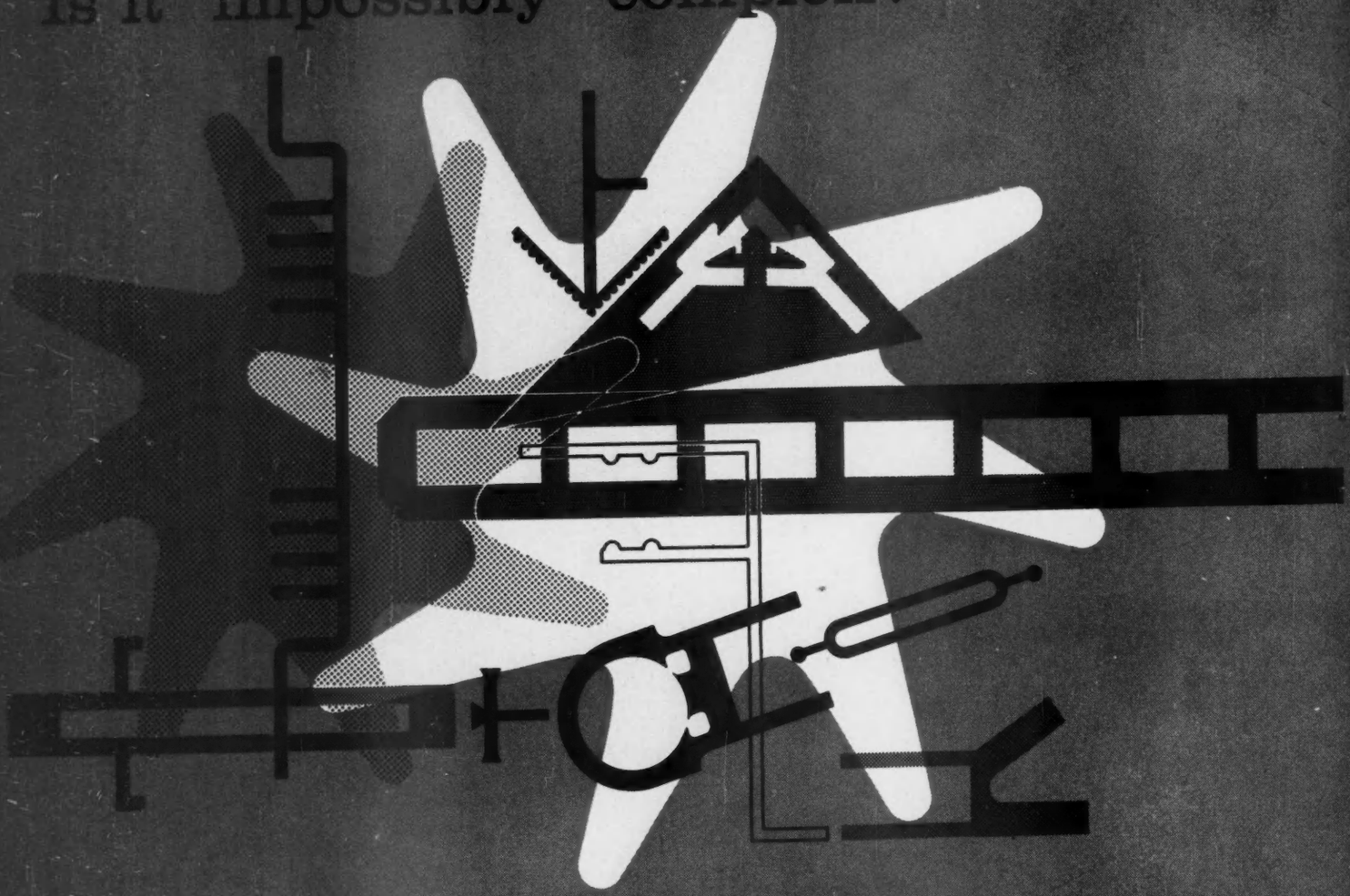

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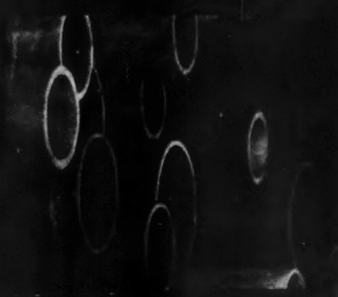

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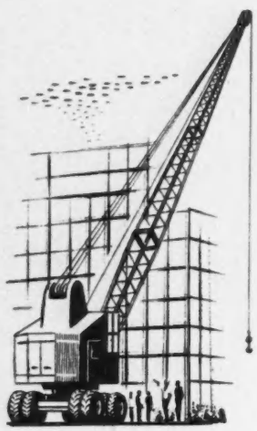

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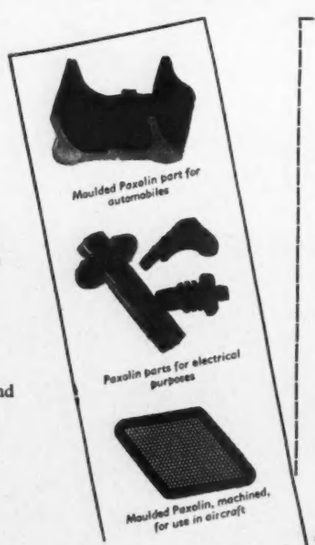
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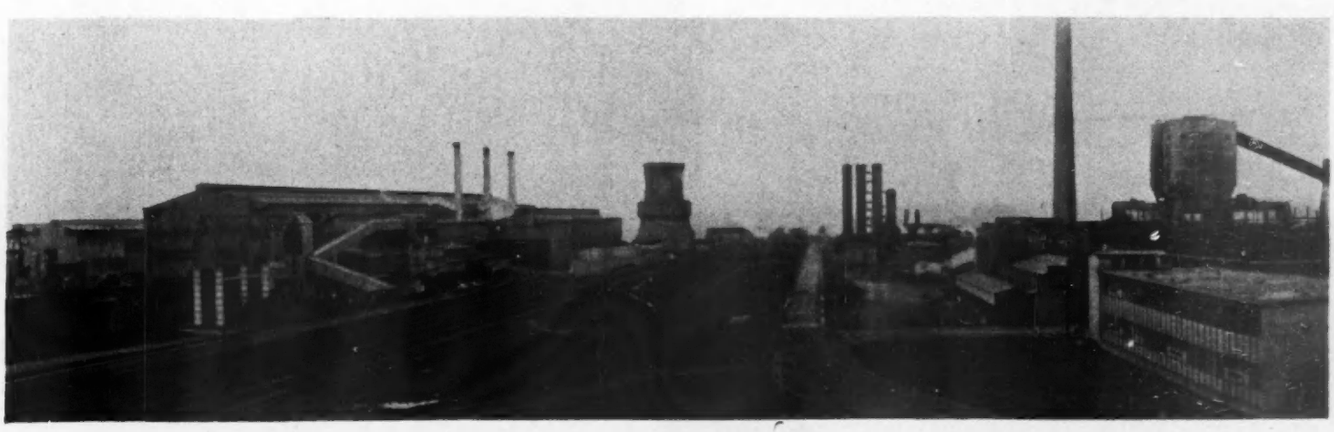

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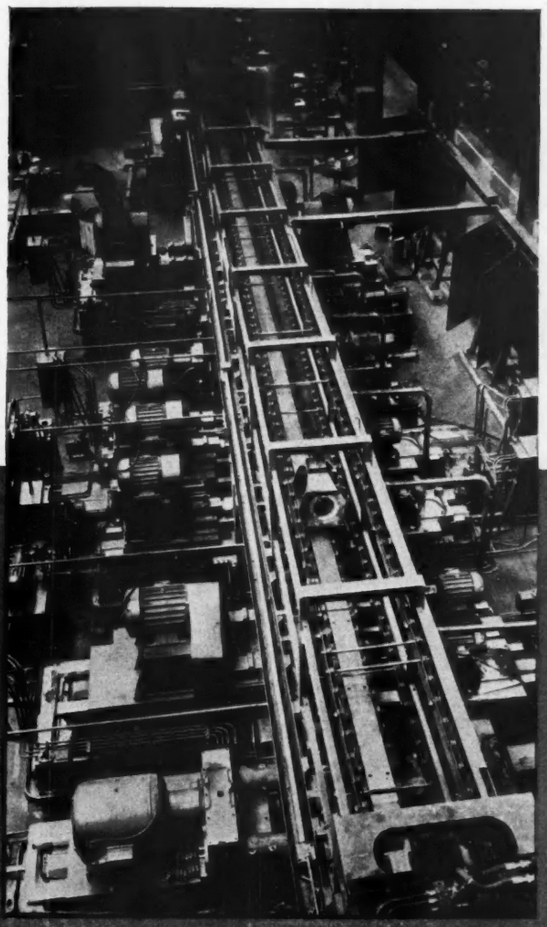
These two elevators in a Dutch quarry are equipped with Renold 6·0 in. pitch 30,000 lb. breaking load chain and are 82 feet high. They have a combined capacity of 220 tons of marl per hour.

SEE OUR STAND NO. GG.19 AT THE MECHANICAL



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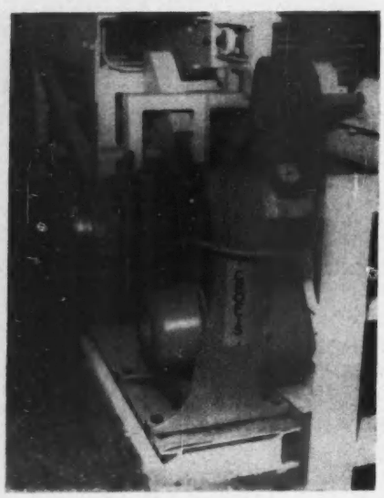

A Vertical Unit in use on cereal processing machinery. (Guards removed for clarity.)

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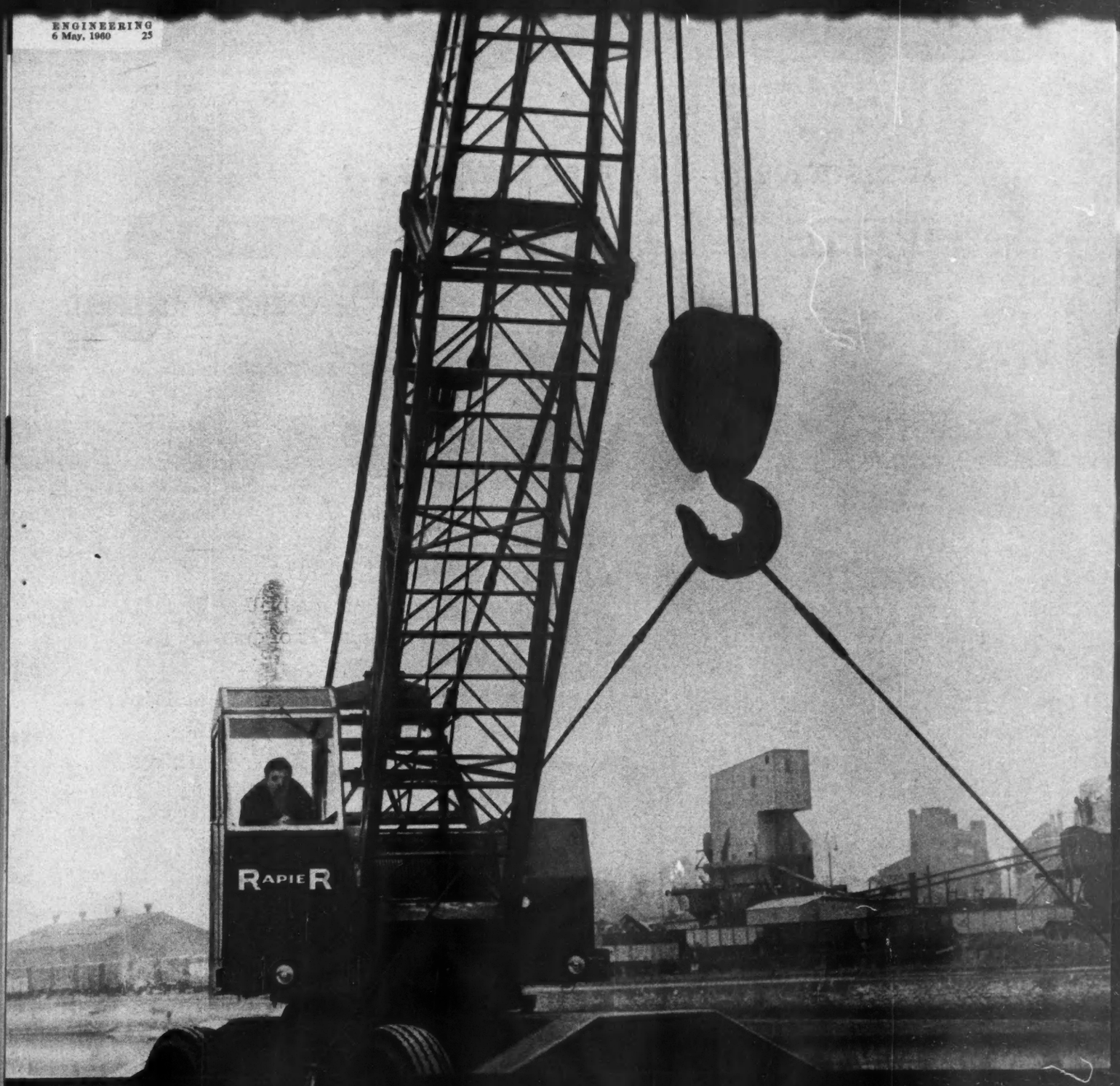

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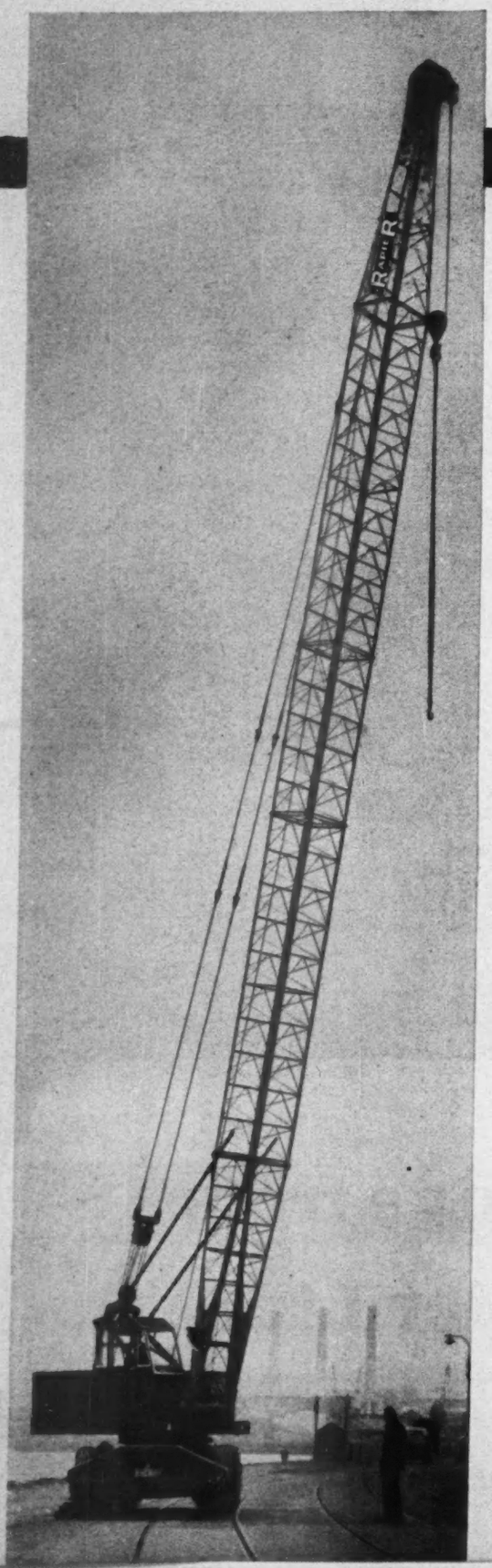

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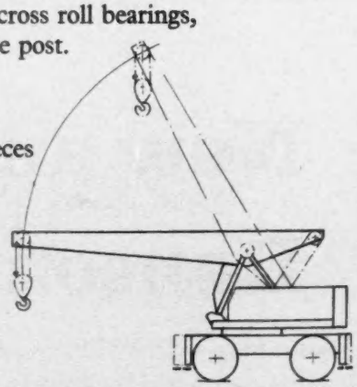

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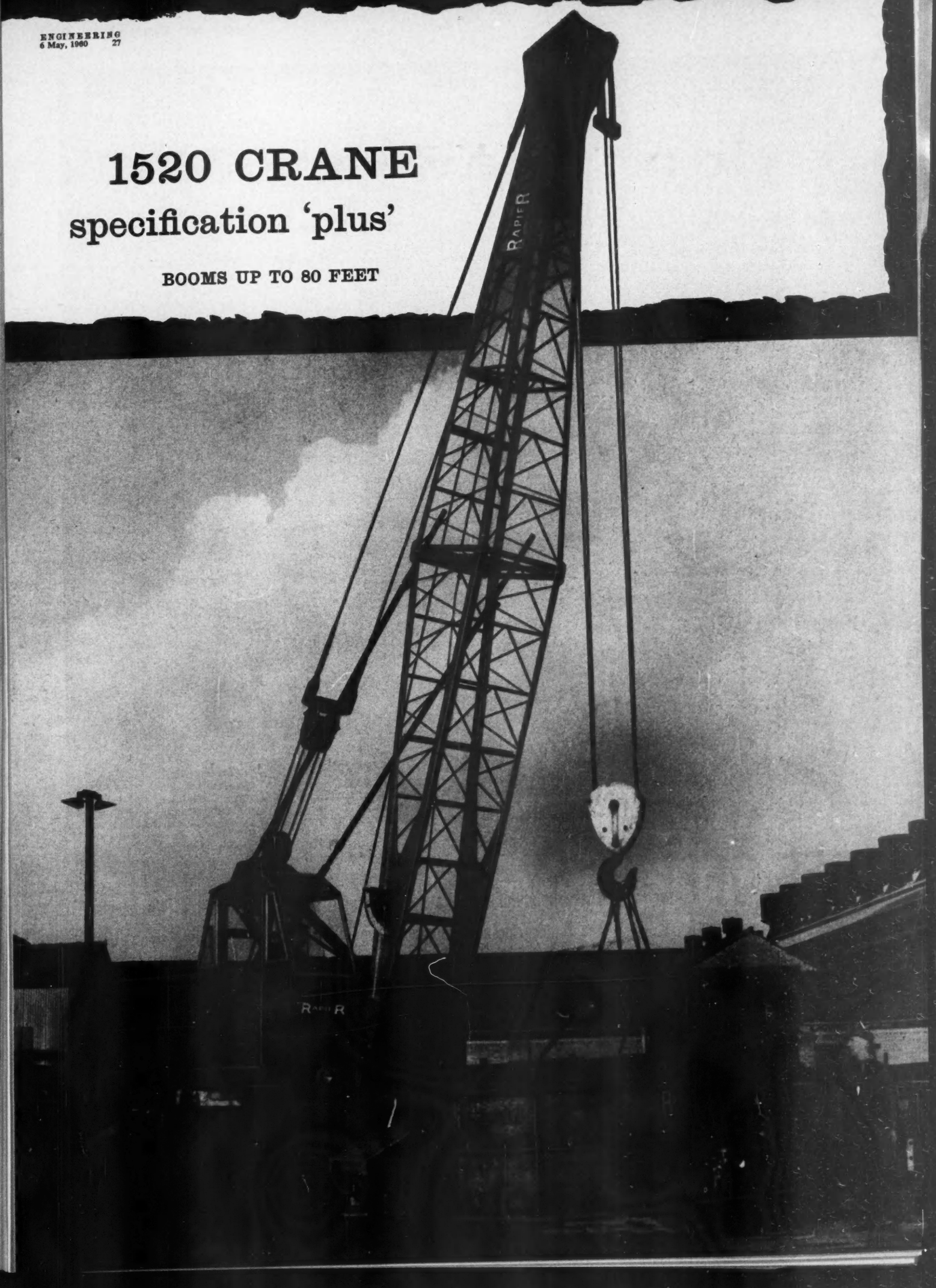
BOOMS UP TO 80 FEET



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With these Glacier handbooks by you the drawing of most Plain Bearings is quite unnecessary. All you need do is quote the part number. These handbooks will save you and your company time and trouble—and that means money.

HANDBOOK NO. 1 ON STANDARD BEARINGS gives complete technical data on fits, finishes, tolerances, housing diameters and clearances; advice on assembly, operating conditions etc; also tables of standard sizes of machined bronze bushes, wrapped bushes, dry bearings and bearing materials. All these bearings are available from stock on quotation of a single part number.

HANDBOOK NO. 2 ON DRY BEARINGS AND MATERIALS gives all data on properties dimensions and tolerances for DU and DQ Dry Bearings and Materials—as well as DG and DL process treatments.

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These handbooks—the first two of a series—are part of the service The Glacier Metal Company offers to designers and draughtsmen

We will send any company, on receipt of an official request, copies of the Glacier **DESIGNER'S HANDBOOK NO. 1 & 2** for each of its draughtsmen.

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He's a casting director of many parts...

... and the results of his work give excellent performance.

For, whatever casting process is required for *your* production—cement-sand, shell-moulding or 'lost-wax'—the team of experts at David Brown Foundries Division carries it out with supreme skill and care.

There is no proven method of casting that is not within the scope of the division's resources. There is no recognised technique of testing that is not used at Penistone. Inspection by X- and gamma-radiography, by photo-electric absorptiometer and by spectrograph, are standard. Electromagnetic flaw detection is applied to all steel castings for aircraft and other special applications.

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An alliance of engineering specialists in gearing, machine tools, castings, automobiles and agricultural tractors and machinery.

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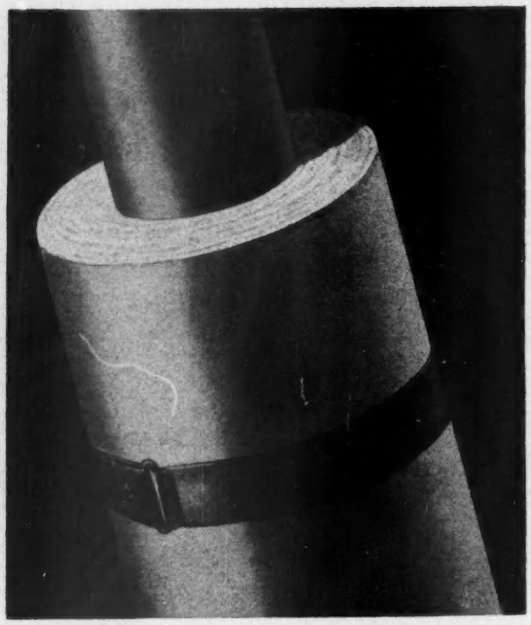
OA/5661

"I was Cool, Man, Cool!"

'Steamy' Pipe reminisces

"It's my job to carry steam — and to keep it at s-s-s-steam heat. But I was falling down on the job — as flat as an old fashioned waltz at a Rock 'n Roll Rally. I was losing heat. Wasting fuel. Throwing away money. If I hadn't been so round, you could have called me a square. What a difference when they fitted me from top to toe in Fibreglass Rigid Sections! Man, these sections are really something! They're light; they're trim; they go on easily and stay on permanently. Since they came along, I've been the savingest pipe in the business; *and* I keep the steam just as it should be — piping hot!"



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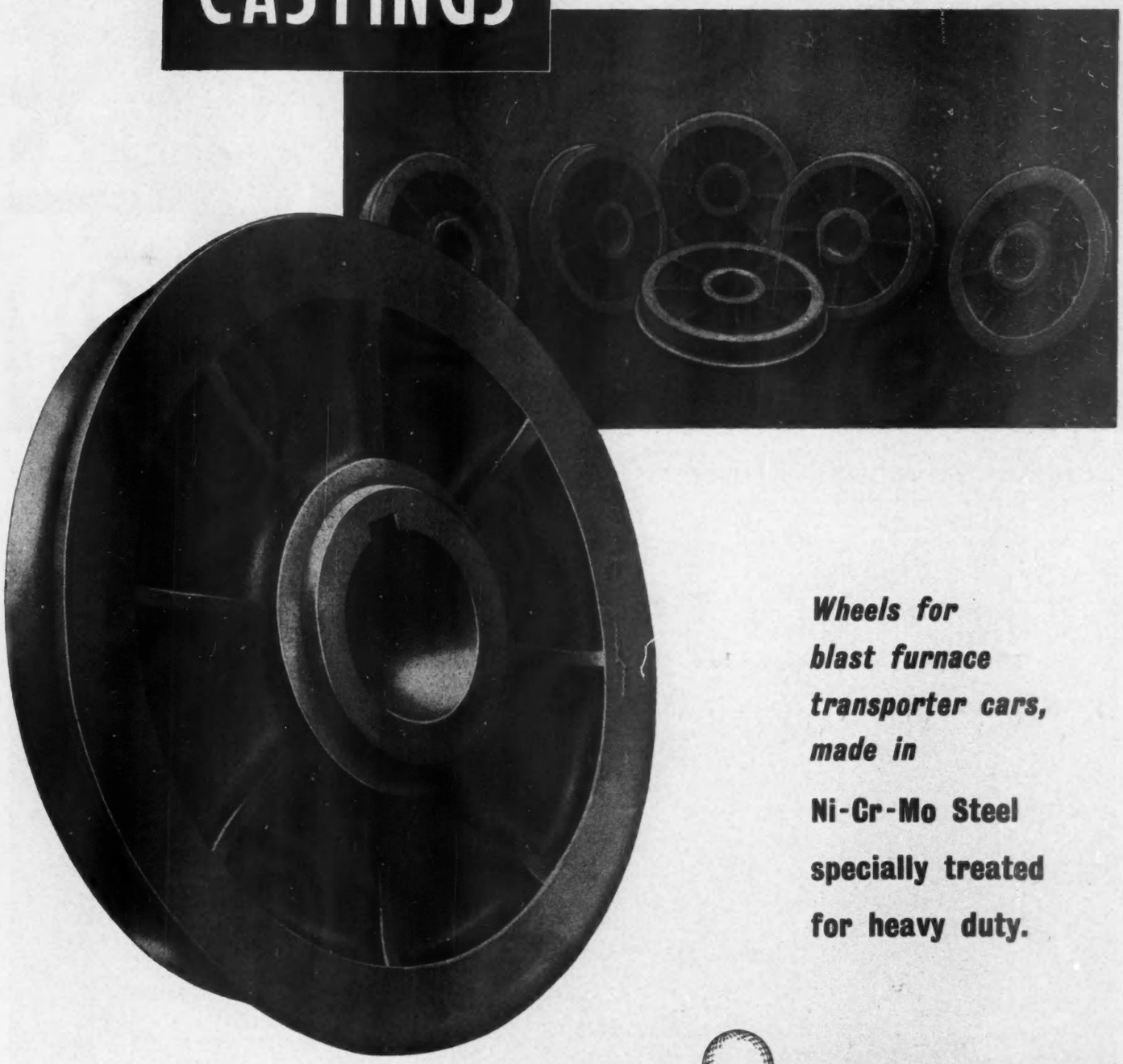
STEEL CASTINGS



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Ni-Cr-Mo Steel specially treated for heavy duty.

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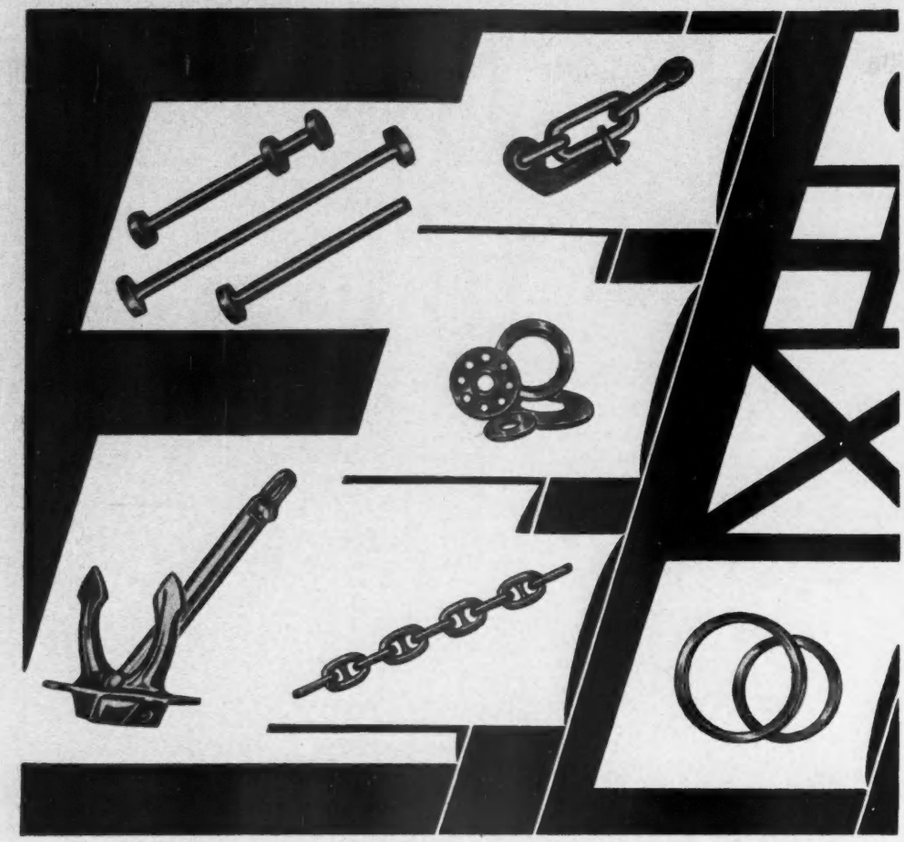

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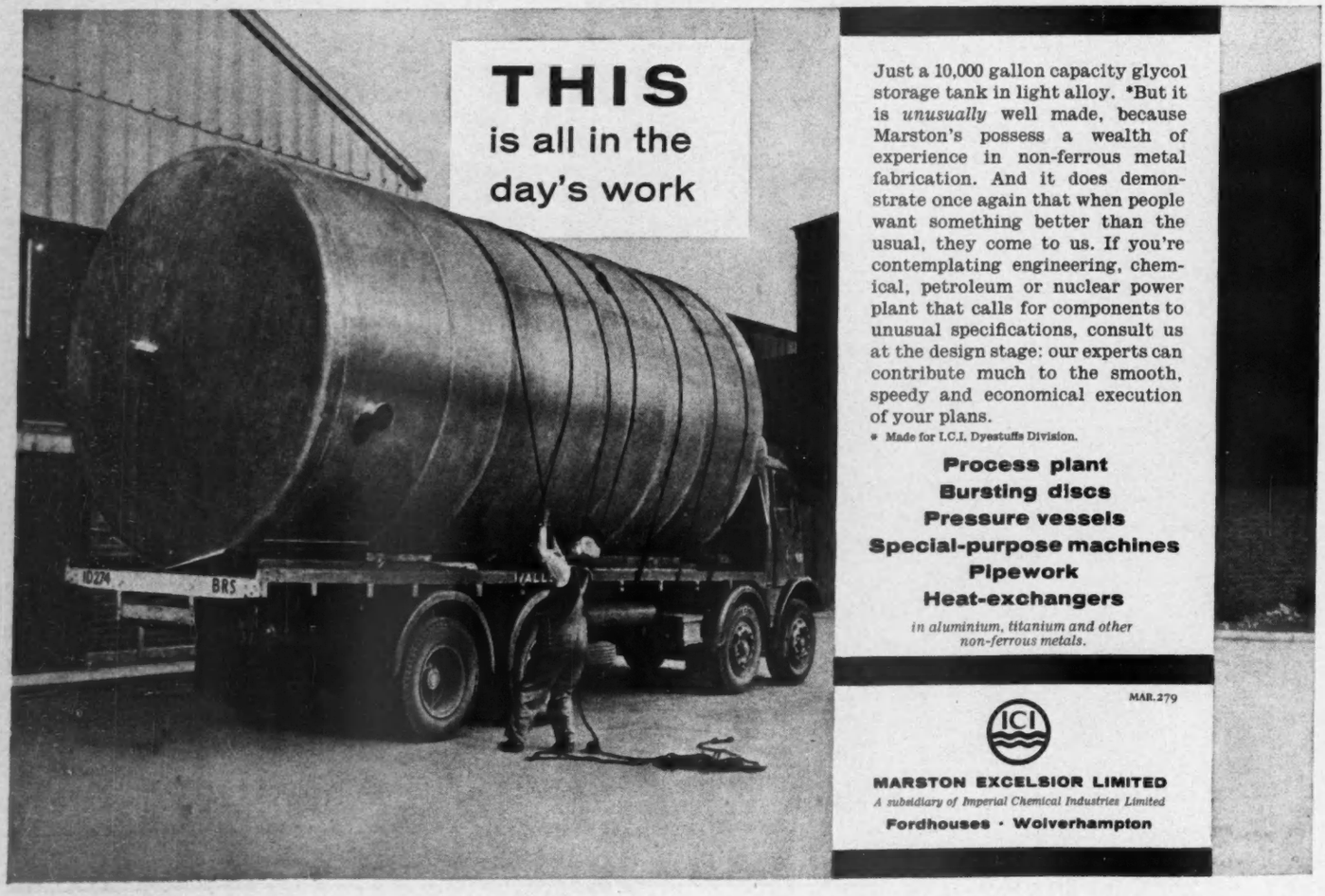

Just a 10,000 gallon capacity glycol storage tank in light alloy. *But it is *unusually* well made, because Marston's possess a wealth of experience in non-ferrous metal fabrication. And it does demonstrate once again that when people want something better than the usual, they come to us. If you're contemplating engineering, chemical, petroleum or nuclear power plant that calls for components to unusual specifications, consult us at the design stage: our experts can contribute much to the smooth, speedy and economical execution of your plans.

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in aluminium, titanium and other non-ferrous metals.

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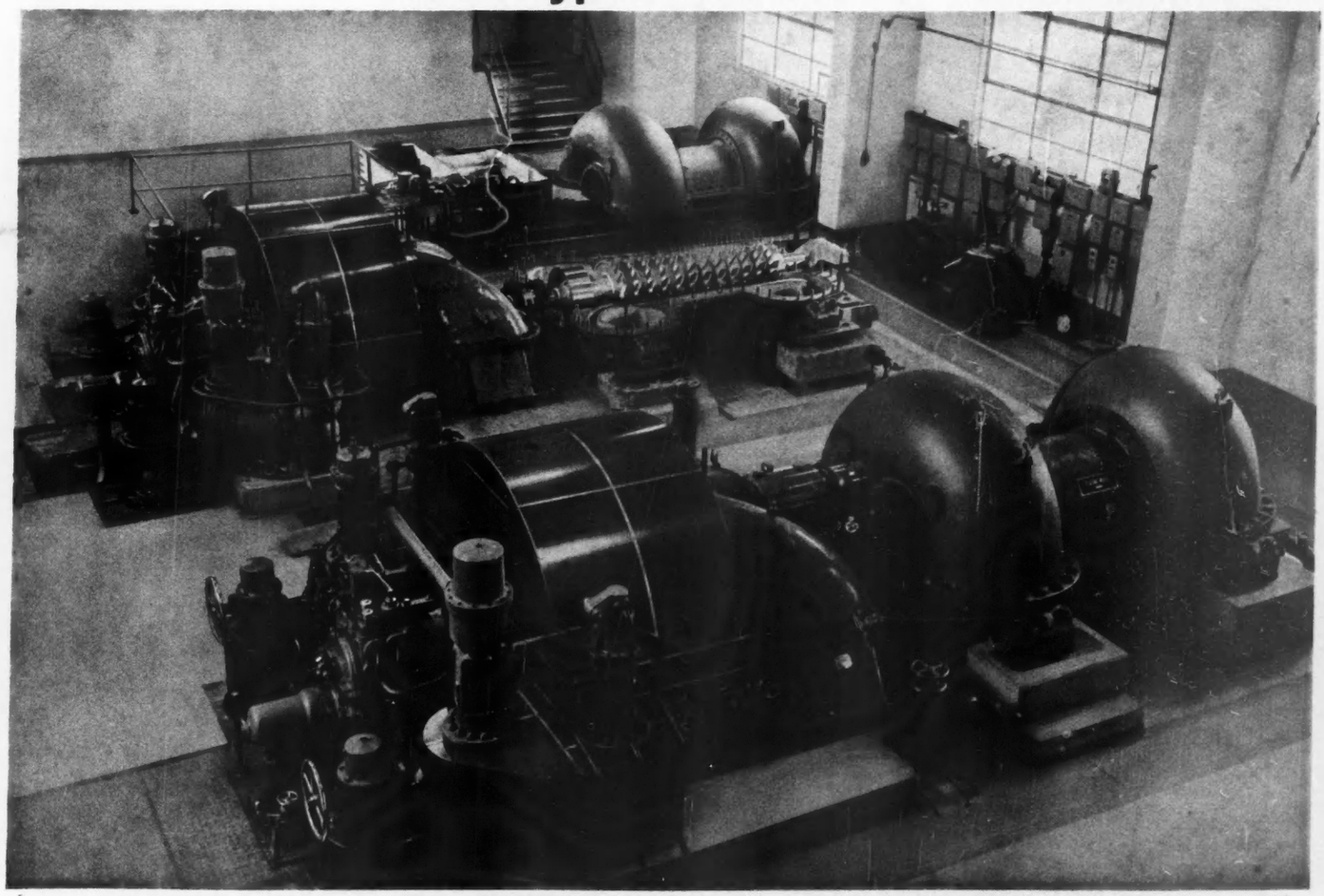
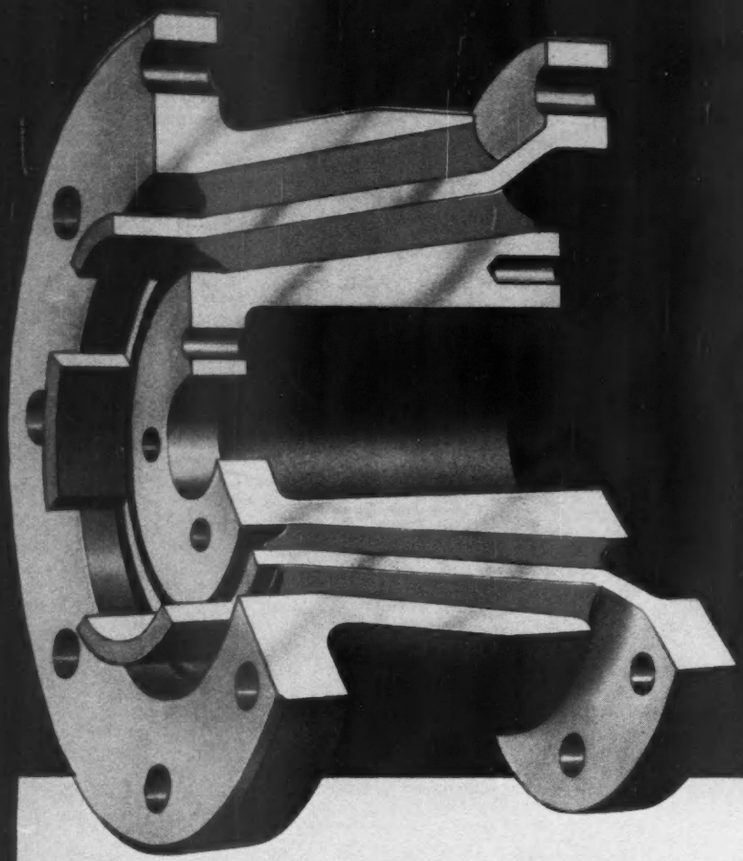


London Office: Escher Wyss Ltd., Terminal House, Grosvenor Gdns., London S.W.1, Phone Sloane 6101

Escher Wyss Ltd, Zurich (Switzerland)

D3



Double-cone couplings

(PATENTED)

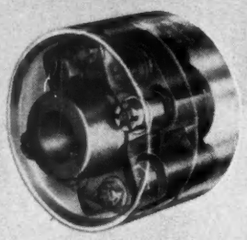
Damp Torsional Vibration, Resist Thrust, Absorb Shock Loads

A high degree of torsional flexibility combined with large torque capacity singles out the Double-Cone Coupling for drives in which torque fluctuations and torsional vibration must be controlled.

The design is suitable for torques up to 100,000 lb. ins. and torsional deflections from 5°-10°. It permits some angular misalignment and is designed to resist end thrust.

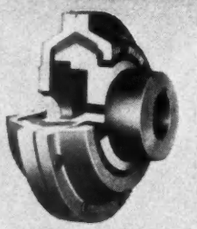
Available in a number of standard sizes, the Double-Cone Coupling is of robust construction and requires no maintenance.

SOME OTHER METALASTIK COUPLINGS



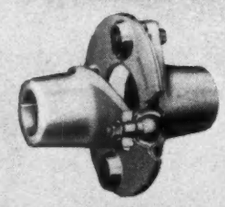
TRAILING LINK

Accommodates exceptional parallel misalignment. In range of sizes to transmit 1-20 h.p. per 100 r.p.m.



BICONE

For marine and other applications, transmits thrust, absorbs torsional vibration and accommodates misalignment. For drives of 5-10 h.p. per 100 r.p.m.



UNIVERSAL

Accommodates a large amount of angular misalignment with very low resistance. In sizes to transmit 0·3–3 h.p. per 100 r.p.m.

METALASTIK

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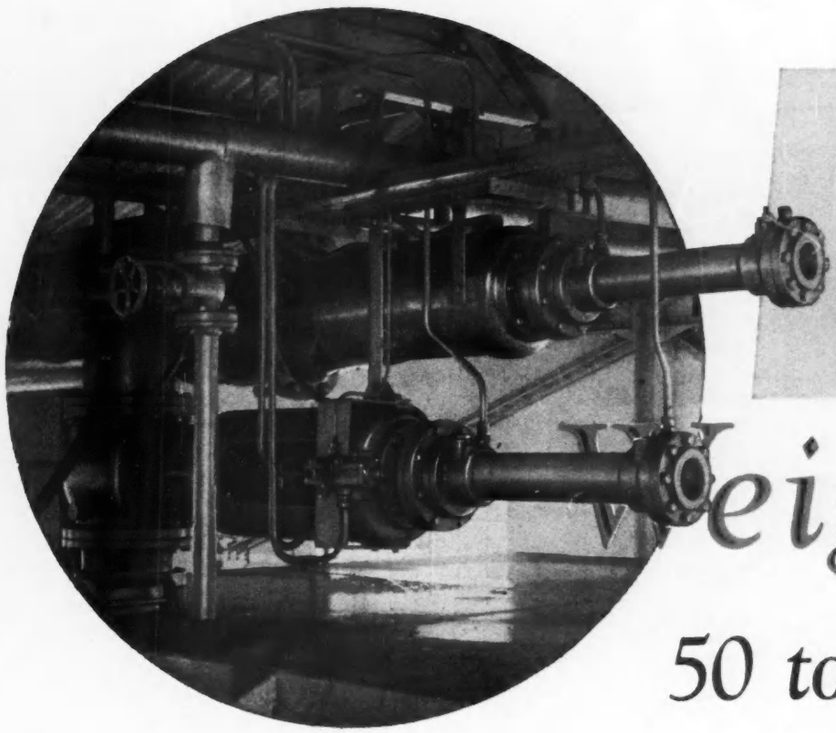

LOCKHEED HYDRAULICS . . . and MARGARINE

Weighing 50 tons of oil

AT Van den Berghs and Jurgens' Purfleet factory, edible oils for making margarine are pumped ashore at the rate of 600 tons per hour, and have to be weighed as they flow—without any interruption. Oil is pumped into one or the other of two tanks, each of which can hold 50 tons, and is supported on a weighing machine. These are shown below, on each side of the Lockheed console. When the oil reaches a certain level in the first tank the flow is automatically diverted to the second tank.

By pushing a button on the Lockheed control, the operator now weighs the oil

in No. 1 and then opens discharge valves and sends the oil on its way to the storage tanks ashore, and the cycle recommences with tank No. 2.

The top illustration shows weigh tank No. 1 with its inlet valve and (above) the main isolating valve (normally open) in the tanker-discharge pipeline.

This is but one of the many examples of Lockheed labour-saving in industry.

Our publications show many valuable units and interesting applications. May our representative bring you copies ?

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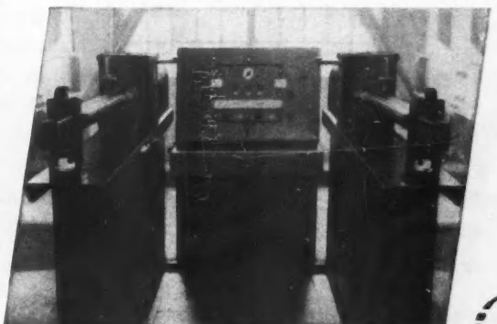

Regd. Trade Mark

Lockheed

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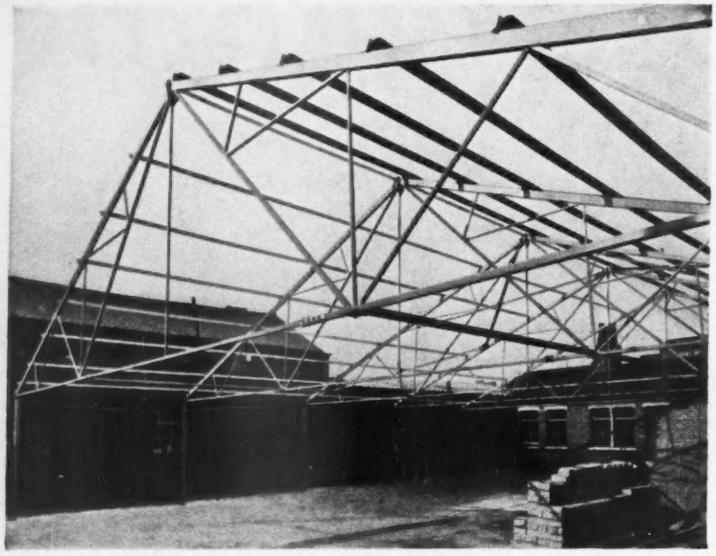
ONE OF THE AUTOMOTIVE PRODUCTS GROUP

How they use R·H·S For Building Frameworks

Alltons (Structural Steel) Ltd. of Ripon



This single storey 60′ span warehouse was erected for one of our appointed R.H.S. stockists, Macnays Ltd. of Middlesbrough, by Alltons (Structural Steel) Ltd. of Ripon, Yorks. The stanchions and roof trusses were constructed entirely from R.H.S. and designed to comply with the requirements of BS 449:1959.

Rectangular Hollow Sections (R.H.S.) are now being used for a wide range of mechanical and structural purposes. The sizes available in the Stewarts and Lloyds' range of hot-formed sections are listed in the accompanying table. R.H.S. eliminate the need for special shaping of components before welding. Any straight-cut R.H.S. or tube will fit accurately against their flat sides whether square-on or at an angle and, moreover, lugs of various kinds produced from tube or bar are easily attached. Welding is simple and no bevelling is necessary.

Our subsidiary, Tubewrights Ltd., of 25 Buckingham Gate, London, S.W.1, is willing to advise on or quote for any welded sub-assemblies.

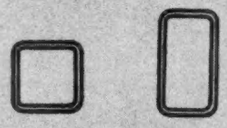
STEWARTS AND LLOYDS WAREHOUSES THROUGHOUT THE COUNTRY STOCK R.H.S.

Pamphlet giving full dimensions, properties and prices will be sent on application to:—

Stewarts and Lloyds Ltd

STRUCTURAL STEEL DEPARTMENT, BROAD STREET CHAMBERS, BIRMINGHAM 1

Telephone: Midland 2700. Telex: 33333



FROM	FROM
1″x 1″	1⅞″x 1³⁄₁₆″
TO	TO
5″x 5″	6″x 4″

R.H.S. ARE PRODUCED TO THE PHYSICAL PROPERTIES OF B.S. 1775 GRADE 16

STEWARTS AND LLOYDS S&L RECTANGULAR HOLLOW SECTIONS TUBEWRIGHTS

ALL WELDED FABRICATION

PROVIDES A STRONGER MORE ACCURATE SPUR WHEEL AT LOWER COST

RIM
High Tensile Steel
pressed to shape

CENTRE
Mild Steel
Fabrication

all welded by ½ in. penetration process.
Two halves bolted together.

This method of construction supersedes the conventional casting for spur wheels—patterns are not required, and the total elimination of distortion means no rejects. The cost is lower, delivery is faster.

The rings are immensely strong and more accurate; machining, done by customer is simpler, life is longer: can be stress-relieved if required.

SIZES FROM 5 FT. DIAMETER UPWARDS
TO ALL REQUIREMENTS

for Machine Tools, Cranes, Mechanical Handling Equipment, etc.

Extensively used by Butters Bros. in heavy cranes.

The STEEL CONSTRUCTION COY. LTD

WHITEGATES ENGINEERING WORKS,
MOTHERWELL · SCOTLAND
AN ASSOCIATED COMPANY OF BUTTERS BROS. & CO. LTD.

COLD ROLLED STEEL STRIP

MILD, MEDIUM AND HIGH CARBON
TRUBRITE STAINLESS STEEL STRIP

ALSO PRODUCERS OF BRIGHT STEEL BARS, HIGH STRAIN AND STAINLESS STEEL WIRES.

The best raw materials—the finest and most up-to-date production plant and rigorous inspection—ensure that LEE'S Steel is constantly true to specification.

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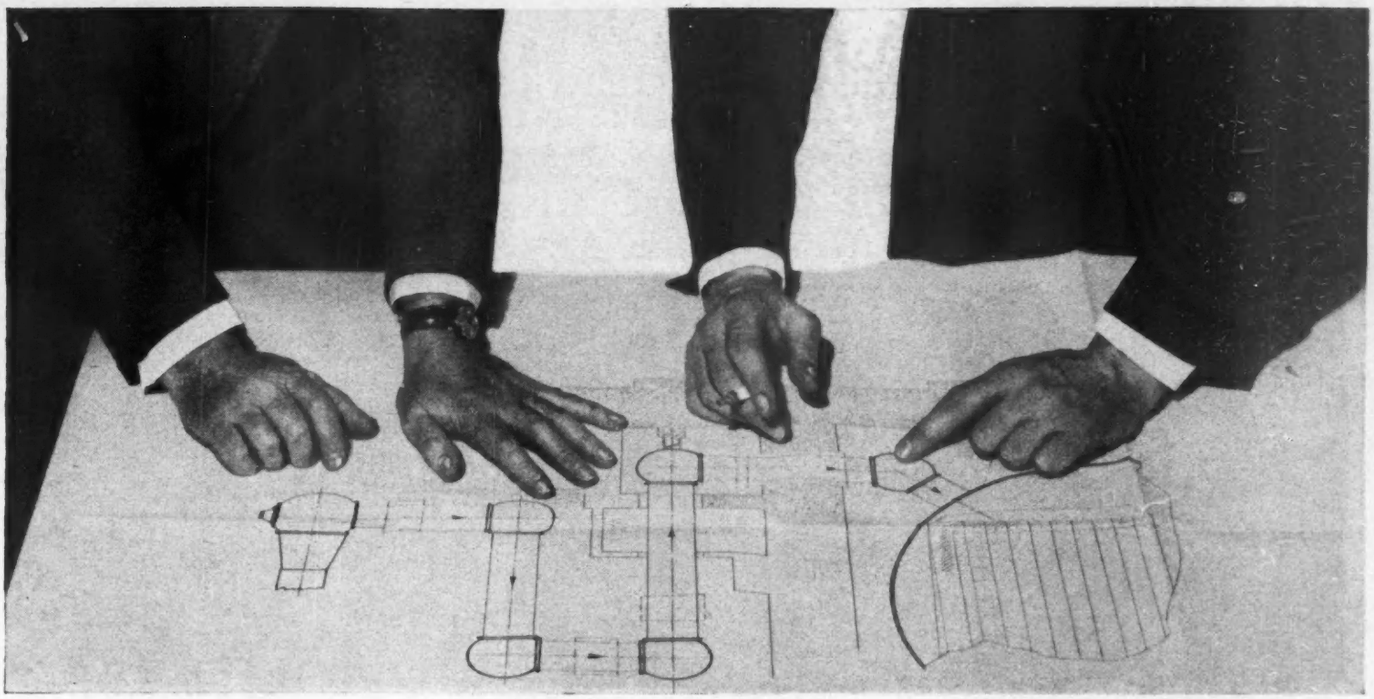
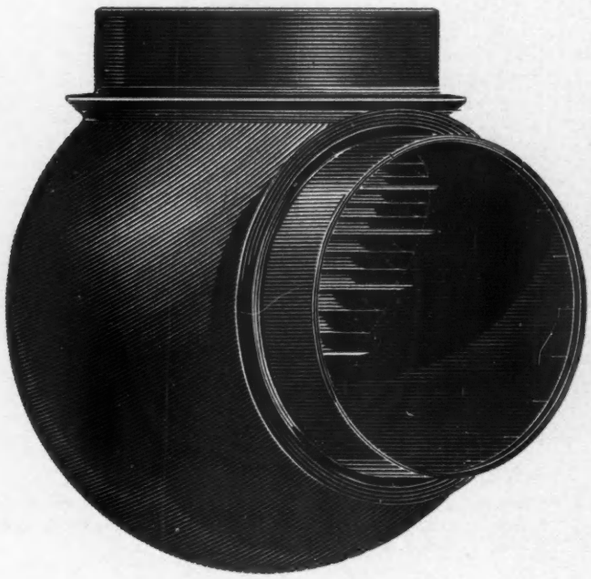


YOU COULD HEAR A PENNY DROP...



We spread out the drawings . . . an instant of surprised silence; then that gratifying sound. It is usually something like "Of course! Why didn't somebody think of that before."

Why not indeed? All we have done is to make the bends in the CO_2 pipework of an atomic reactor, spherical. Any schoolboy with G.C.E. physics knows the formula for the thickness of a pressure vessel—

Cylindrical: $t=\frac{P.R.}{S}$ Spherical: $t=\frac{1}{2}\frac{P.R.}{S}$

So with a sphere you can halve the thickness of the plate. But that is only the beginning. Bonuses roll in. All welds become circular, can be made by machine and can be X-rayed easily and completely. There are no uncertainties—no stiffening webs, for instance, attached by welds which cannot be X-rayed. The guide vanes are part of a lightweight duct, inside the sphere and thus unstressed by pressure.

A simple and indeed an obvious idea; but it can save large sums of money on the cost of a power station or a wind tunnel. The fact is it is not easy to see the obvious; the orthodox approach, the standard answer, get in the way. However, some of our engineers seem to be able to do it, thank goodness.

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RW53

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"A bit rough, being on piece rates and having one in five rejected, not to mention all the hold-ups for machine servicing, but with R.T.D. I can work fast right through the shift without a sign of trouble."

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"Spent more time on that machine than all the others in the shop. Now with R.T.D. tool life has gone up by as much as 200%.

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"Nobody likes to reject as much as 20% of a man's work, but because of inferior surface finish I had no option. But with the introduction of R.T.D. rejections fell to 5% overnight."

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"Production difficulties not only forced our price up but caused delivery delays as well. Now with R.T.D. we're ahead of our competitors on both price and delivery."

Try R.T.D. Compound for yourself. ***SEND FOR A FREE TRIAL SAMPLE TODAY*** *and see the instant improvement that it brings!*

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"BROOMWADE" fit VISCO air filters

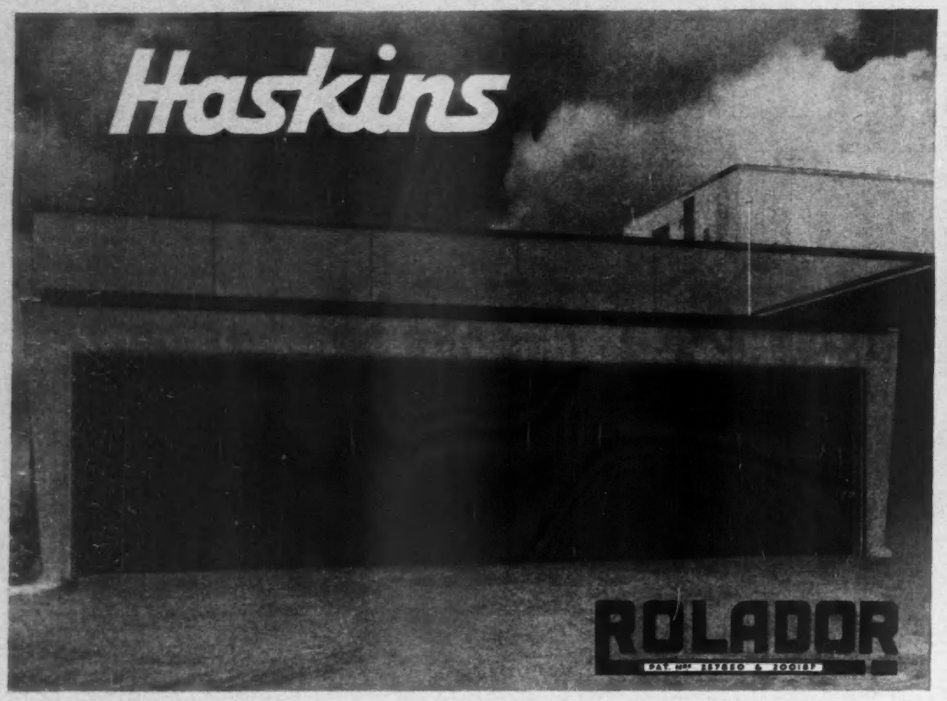
Photograph by courtesy of Vauxhall Motors Ltd., and Broom & Wade Ltd.

When AIR FILTERS are needed, it is significant that leading manufacturers specify "VISCO". Illustrated is a battery of "BROOMWADE" Type TS2X Air Compressors, installed at the Dunstable Works of Vauxhall Motors Ltd. Each Compressor, fitted with a "VISCO" Filter, delivers 1,000 cu. ft. of free air per minute and practically runs on continuous duty for long, trouble-free periods with a minimum of maintenance— a tribute to both "BROOMWADE" and "VISCO". It will PAY YOU to consult THE VISCO ENGINEERING CO. LTD., STAFFORD ROAD, CROYDON. Croydon 4181.

VISCO

Air Filters

PWS



Haskins Electrically operated ROLADOR Steel Rolling Shutters installed for the Liquor Control Board of Ontario, New Warehouse, Ottawa, Canada. Traversing type pilasters separate three independently operated shutters.
Architects: Messrs. Balharrie, Helmer & Morin, Ottawa. General Contractors: Thomas Fuller Construction Co. Ltd., Ottawa.

Haskins *ROLLING SHUTTERS & GRILLES*

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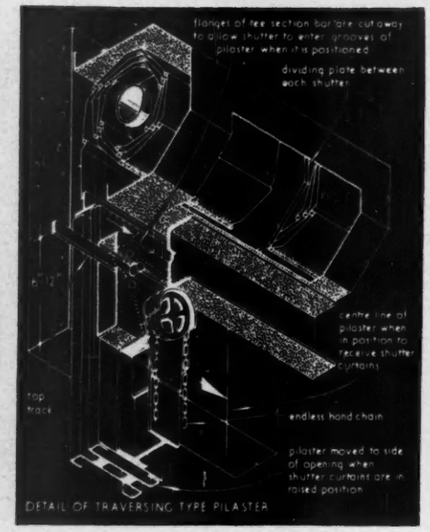
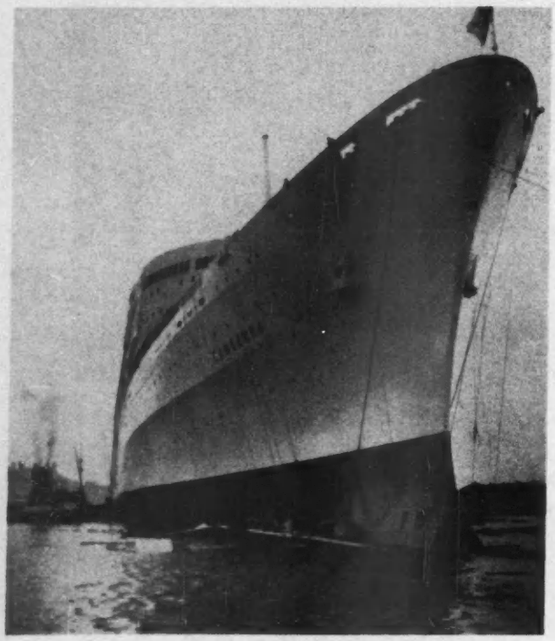

flanges of tee section bar are cut away to allow shutter to enter groove of pilaster when it is positioned
dividing plate between each shutter
centre line of pilaster when in position to receive shutter curtains
top track
endless hand chain
pilaster moved to side of opening when shutter curtains are in raised position
DETAIL OF TRAVERSING TYPE PILASTER

STEEL ROLLING SHUTTERS

WITH TRAVERSING TYPE PILASTERS

Traversing type pilasters can be moved to side of opening when Shutter curtains are in the raised position. This allows either a section or the whole unbroken width of the opening to be worked as required.
This is but one of the many ways by which Haskins Shutters provide security to any opening of any width and of any height.

Full details of Haskins Steel Shutters and illustrated catalogue on request.



the new P. & O. liner

s.s. "CANBERRA"

being built by Harland & Wolff Limited, Belfast

is fitted with 68 tons of "KUNIFER 30" condenser tubes

manufactured by

YORKSHIRE IMPERIAL METALS LIMITED

YORKSHIRE IMPERIAL

HEAD OFFICE — P.O. BOX 166, LEEDS

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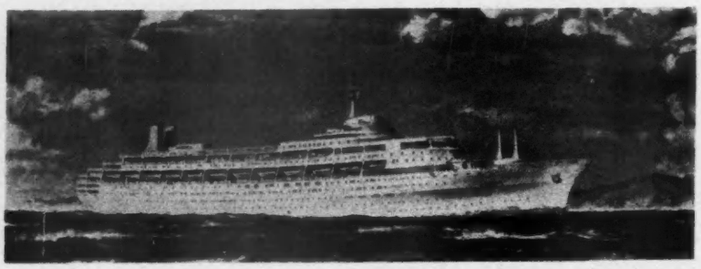
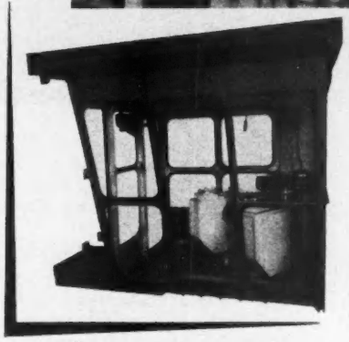


JOSEPH ADAMSON
ELECTRIC OVERHEAD TRAVELLING CRANES



★ *a view of the cab showing the seat control unit.*

The Adamson 50/10 ton crane is the third of a series of new design supplied to Richard Thomas & Baldwins Limited, Ebbw Vale Section. Features of the crane include monolithic construction of the crab and the elimination of castings by mild steel fabrication of the hoist barrel and bottom block. The cab is of particular interest as it incorporates the most modern type of seat unit ensuring maximum visibility and ease of control. Joseph Adamson electric overhead travelling cranes can be supplied to all specifications including cranes suited to the most exacting 24 hours-a-day process work.

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The Horsehay Company Ltd., Wellington, Shropshire

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JA 25

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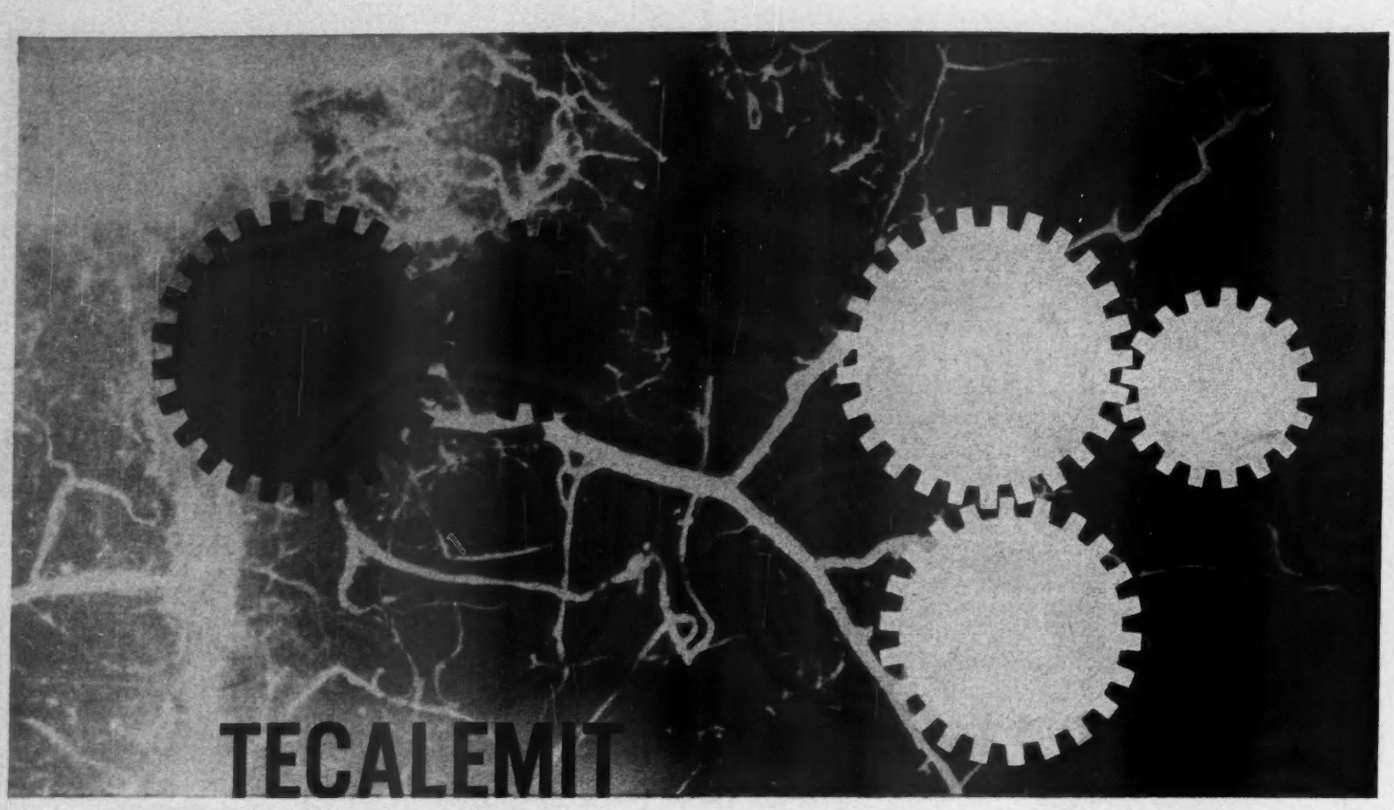

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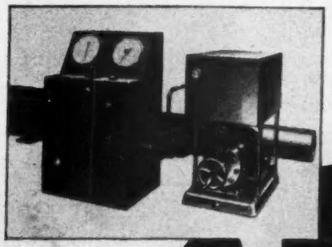
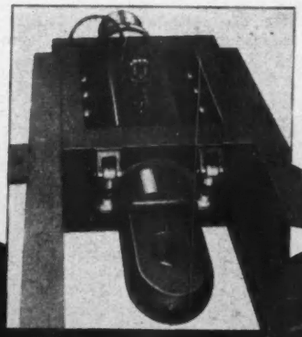
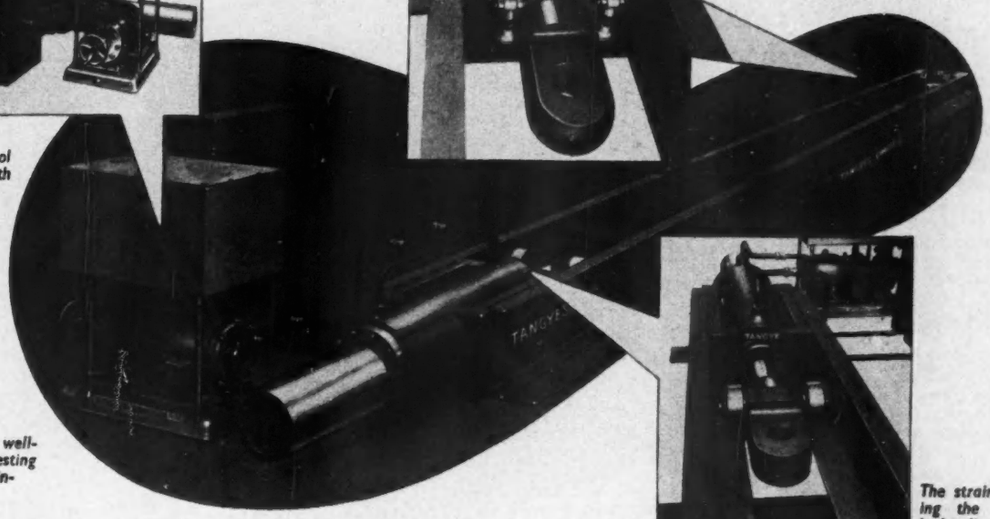
TANGYE CHAIN TESTING MACHINES



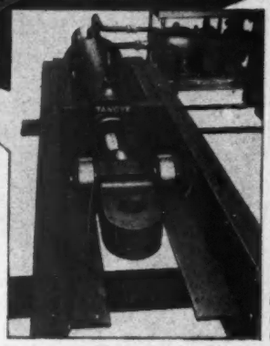
View from operating position showing control Cabinet and pump with oil reservoir.



The resistance head showing linkage support to eliminate friction. Hydraulic capsule and capillary tube also show.



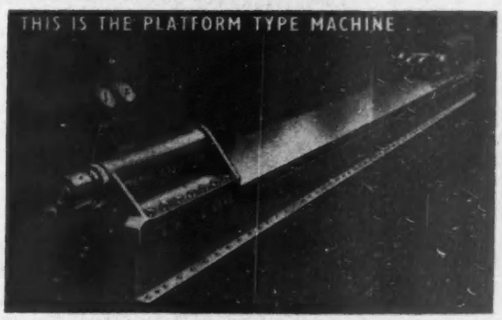
A Tangye 100 tons well-type chain testing machine recently installed.



The straining end showing the double acting hydraulic cylinder and roller supports for the ram and tension rod.

This range of machines is for testing chains, shackles, complete lifting blocks, large rings and similar gear. One of the many features of these machines is the use of a tension rod which is suspended on links to take its weight and the weight of the specimen, thus preventing the rod contacting the bore and constituting a resistance. The pull being applied during a test is registered by a sensitive load capsule located on the tension rod, the capsule in turn being connected via capillary tubing to a dial-type load indicator. Two types of machine are supplied, 'Platform' or 'Well' types, and these can be arranged for almost any working load, stroke or length. Examples of dimensions and capacities of machines now in use, are shown in the table.

FULL INFORMATION IS AVAILABLE ON REQUEST



EXAMPLES OF CAPACITIES OF MACHINES NOW IN USE SHOWN BELOW.

	Platform Type				Well Type			
Working Load. *In Tons*	50	75	75		15	30	50	100
Stroke of Straining End Piston. *In inches* ..	36	36	36		30	30	30	36
Centres of Eye Ends on Tension Rods	30′	34′	16′		20′ 6″	30′ 6″	25′ 9″	51′

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MAGNETIC CRACK DETECTION APPARATUS

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INSTRUMENTATION DIVISION—Scientific Apparatus & X-Ray Department
Trafford Park, Manchester 17

N/R001

ENGINEERING Impact

of Twenty Per Cent Down and Two Years to Pay

THE Chancellor of the Exchequer's gentle credit squeeze, little as it may affect the expansion of the industrial giants, will once more bear heavily upon the small, developing manufacturer.

For the largest firms, capital has largely been raised, since the war, from operating resources and through the Stock Exchange. There is no change in that position.

But for the newer, smaller company, with new ideas and new techniques to perfect, it has been difficult enough to find sufficient money even in the relatively easy period since the controls were taken off early in 1958. Now, with the chilling assertion that companies rather than private individuals will be confronted with pressure on their overdrafts, the situation that produced a number of mergers, in for example electronics, last year, has become appreciably sterner.

There is something of a slightly silver lining to this cloud, which since there is no election to be won may not be all that quick in passing. However slight, there is bound to be some lessening in home demand now repayment instalments in hire purchase are 50 per cent greater—the practical effect of paying back over two years instead of three.

And that gives engineering companies a useful opportunity to improve on delivery dates overseas. Some concern has been shown in Canada over a growing length of delivery from some United Kingdom firms. All the publicity in the world cannot maintain the demand it may have sparked off if the deliveries are not there and there on time.

Canada may well not be the only example. But it is a good one. British exports, cars included, have been expanding in the Dominion.

Mr. Amory's little hug may help us to do even better.

American Cooperation in Italy's Nuclear Progress

When the thunder of the French atomic explosions subsided the impression was left that, whether they had been diplomatic or not, plainly the nuclear industry of France was making useful strides.

Now, with much less resounding news, a piece of the jigsaw falls into place to reveal that the major atomic power on the continent of Europe may not be France but Italy.

One more American industrial concern has reached agreement with an Italian company. In this case it is Allis-Chalmers who are to cooperate with the Italian CNRN, setting up joint research, with one research station in Italy and another in America.

The list of earlier agreements includes Westinghouse Corporation with Fiat, Babcock and Wilcox (America) with Cantieri Riuniti dell'Adriatico and General Electric Company of America with SENN.

The latest addition to the list is important for it shows that the Italian nuclear industry is developing most rapidly—and along lines similar to those in America.

Yet it was not a foregone conclusion. Britain achieved one agreement, that of the Nuclear Power Plant Company, who are building the Latina nuclear power station south of Rome.

What the Italians can do, with the help of the United States companies, others may want to emulate. When the opportunity comes, or is found, another chance will be available to spread some of those heavy overheads.

The Speed of Change

It is a dangerous fallacy to assume that long experience will ensure industrial leadership. In sport, the man who comes from behind has many advantages and rowing in the lee of the leader can close the gap in a matter of strokes. Some sobering examples are on our doorsteps.

Where was the French aircraft industry in 1950? Today, the Caravelle reigns supreme. Russian machine tools, oil drilling equipment and helicopters, Italian injection moulding and business machines, Swedish shipyards, Japanese transistors and German cars are only a few examples of ground made good in a very short time.

Now it is reported that France is bidding for the Indian nuclear power station—competing in our home waters, the gas-cooled reactor. It would be a mistake to assume that the British design is inherently better because of longer experience.

Laurels are perishable and need frequent replacement: There is no room for complacency.

A Royal Charter for Radio Engineers

When 1,200 members out of a corporate body of 4,000 attend, either in person or by proxy, at a meeting of their institution there is obviously some feeling about.

This is what happened with last week's meeting of the British Institution of Radio Engineers. Unanimously the thousand who had sent proxies to the President, and the two hundred there in person, voted for a petition to go to the Queen seeking a Royal Charter for the 35 year old institution.

For the radio engineer, and therefore for radio engineering, an improvement in status would follow the granting of the Charter. In the first place "petitioners" have to approach the Privy Council. This will be done as soon as copies of the document on the history of the institution, already recognised as a learned society, are available.

The mood of the members is one of optimism though there is a feeling that before the Charter is achieved there will be representations made by "another institution." It is no secret that many of those who attended the radio engineers' meeting and many more of those who sent proxies are members of both.

The right to be known as chartered engineers on their membership of the Institution of Radio Engineers alone could lead to an interesting situation. Strongly in the mind of many of these joint members is the feeling that much good would come from co-operation between the leading institutions in the fields of education and allied subjects.

of Great Expectations in the Commonwealth

The Commonwealth Prime Ministers are meeting again, after the usual preliminary wonderings whether so informal a family can avoid breaking up. With the recent bloodshed in South Africa the meetings have been presented in Britain as though race relations, or skirmishing around the subject, are the most important part of the conference.

In reality the greater number of the thirteen sessions are devoted to economic and allied considerations.

And it is on the hard grounds of finance and trade that the countries of the Commonwealth will in time gradually choose between a live and effective association or closer participation in other, regional, groupings.

For the United Kingdom's industries the Commonwealth pattern is changing. The demand for consumer goods, Canada and Australia apart, is not yet growing to an extent discernable at all compared with the need for the equipment and installations to press on with the industrialisation of the emerging nations. In order to approach the point where they can begin producing their own wealth, the Commonwealth countries urgently need capital in enormous quantities.

The three-bankers, visit to India drew attention to the fact that her capital needs are ten times greater than the whole of Britain's considerable yearly outpouring of money to the whole Commonwealth.

If the trend towards the great markets of the Northern hemisphere, the United States, Britain and West Germany, trading together more and more continues, then the raw material producers of the Commonwealth are not likely to suffer a sudden fall in their sales.

But they need more money than they can earn.

Today the opportunity for industry is to export to the Commonwealth the means for each country's advance to prosperity. Tomorrow, if the problem of what to use for money is overcome, the opportunities could be those of selling to hundreds of millions for whom the pressure cooker has replaced the rice bowl.

The Modern Industrial Fair Sets the Pace

From a tolerated and patronised existence the international industrial fair has reached a position of absolute priority for the industrialist concerned to expand or just to stay competitive.

Within the special world of the great competitive fairs things are not all they seem. It may be that the biggest customers do not arrive as visitors at all. They may be the exhibitors themselves.

Professor K. E. Mössner, a member of the board of the German Industries Fair, just held in Hanover, has been thinking aloud on this "elementary point" of the interdependence of the groups of exhibitors. In both finished goods and raw and semi-finished materials the exhibitors are suppliers and customers of each other, says the professor. They account for an important percentage of the effective enquiries.

Of those who do come as purposeful visitors a substantial section are those from Asia, Africa, India and the Middle East, who find in a large well provided fair a ready means of seeing one product against another, one service beside its rival, and at Hanover, no shortage of Ministry representatives able to set out how the government can help.

An obvious comparison can be made with this country's facilities. The German Industries Fair can run heavy exhibits on railway trucks or heavy road vehicles right up to the stands within the halls. The facilities for heavy engineering and the electrical industry are admirably convenient, and most important, sufficiently weight bearing.

The overseas deputation with a programme of industrialisation, of civil engineering, or simply with a general engineering problem, can hardly fail to give priority to a survey of industry as stimulating and comprehensive as that at Hanover.

and Letting the Metre Oust the Inch

A changeover to the metric system of weights and measures is often freely and loosely advocated. The engineering effects of such a change are sketched in impressive detail in the report prepared jointly by the British Association for the Advancement of Science and the Association of British Chambers of Commerce (Butterworths Scientific Publications, 7*s* 6*d*).

When asked specific questions about the advantages of a change, most engineering firms and trade associations were in favour. Little use is made of the metric system in the United Kingdom today except in scientific and instrument applications. But some engineering firms said there had been an increase during the past five years. The cost of a changeover would be very heavy in engineering but practically unpredictable. (A quoted figure of £34 million has little meaning.)

Some of the arguments for not changing over are these. Countries that are otherwise on the metric system use the British and American inch-lb system in certain industries: shipbuilding, oil, aircraft and airlines. Decimalisation of the inch system is already widespread in engineering. The use or non-use of the metric system is not regarded as a particularly important factor in selling abroad.

It would be foolish to change unless the Commonwealth and USA change too. Even among existing metric countries there is not yet a proper range of agreed international standards. Some important measures of international standardisation have been achieved since the war with the inch system (e.g., Unified threads) and should not lightly be abandoned. There is scope for the further rationalisation of our inch-lb units (doing away with "rod, pole or perch").

The report recommends that the Government should institute regular two-yearly reviews in consultation with industry and commerce with the object of studying world trends towards metric usage and thereby deciding on any appropriate action in the future.

In that event, engineering organisations could usefully take a more active part in the reviewing, and not permit science and commerce to dominate.

Simply Coat with "Fluidised" Plastics

Now that a range of powdered plastics is made, the method of dip coating into a "fluidised" powder could well prove a simple answer to your coating problems.

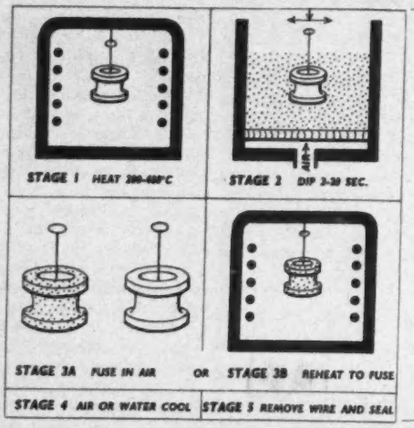
THINK of any plastic. . . . If you would like to exploit it in the form of a coating on a stronger metallic base then there is usually a method of applying it. One of the youngest methods is dip coating into a bed of "fluidised" powder which is now competing with the older methods of liquid application and dip coating into a plastisol.

The uniqueness of many plastic materials is that they are chemically "pure," in other words, they contain only one type of long molecular chain. Chemical resistance of such "pure" materials is often great, but as soon as plasticisers and modifiers are added the resistance drops, as they become prone to leaching out of the additives. This dilution is just what is involved in making liquid dispersions of plastics and in making plastisols; and it is not often that the additives are completely driven off during curing (with a few notable exceptions). Dipping into a bed of powder, especially fluidised, is now proving one of the best methods of applying pure coatings. Other advantages are outlined in the box.

Fluidisation has nothing to do with melting the powder, but is concerned with making it behave like a liquid. This is achieved by passing a diffused current of air upwards through the powder mass. In the fluidised state, the powder is expanded up to as much as twice its normal volume and in this condition it will flow around objects just as a liquid would. Basic procedures and apparatus for the system were developed by Knapsack-Griesham AG of Frankfurt, Germany. In this country, Telegraph Construction and Maintenance hold rights to exploit the process, and they now market a range of fluidising equipment under the name Dipkota.

In the Dipkota tank, the current of diffuse air is obtained by blowing it through a floor made of porous ceramic. To prevent a tendency to "volcano" in which the air flow through the powder is uneven, there is a grid running about an inch from the bottom on nylon wheels, and driven back and forth through about 4 in by an oscillating arm.

Coating procedure then follows quite simply through the steps shown in the top diagram. The metal object is heated up to a temperature between 200 and 400° C depending on the plastic, the thickness required, and the size of article.


STAGE 1 HEAT 200-400°C
STAGE 2 DIP 2-30 SEC.
AIR
STAGE 3A FUSE IN AIR
OR
STAGE 3B REHEAT TO FUSE
STAGE 4 AIR OR WATER COOL
STAGE 5 REMOVE WIRE AND SEAL

Process Characteristics

Simple, clean to operate

Economical for one-off or mass production

No raw material wastage

Uniform coatings even round corners

No solvents used, therefore no fire hazard

But . . .

If transluscent, coatings reveal blemishes

Adhesion is not high, therefore coat all sides

Contamination of powder can cause blemishes

Present coatings only withstand 100° C

Then it is dipped into the fluidised plastic and moved back and forth for a matter of seconds. The plastic melts and adheres to the article, since the preheating temperature is above the melting point of the plastic (unlike coating with plastisols where the plastic is already liquid and just requires warmth to cause it to gel). When it is withdrawn, any powder which adheres to it is shaken off. If it is a large object and has been heated to a high temperature, all that will then be required is to let it cool in air, during the first few seconds of which the coating will fuse and go smooth. Encouragement for small articles with little heat in them is provided by post heating.

Thickness of the coating is determined by adjustment of preheating temperature and of the time the part is immersed in the plastic. Unfortunately, there is no easy formula. But once a procedure has been established, the coatings will be reproducible from one article to the next.

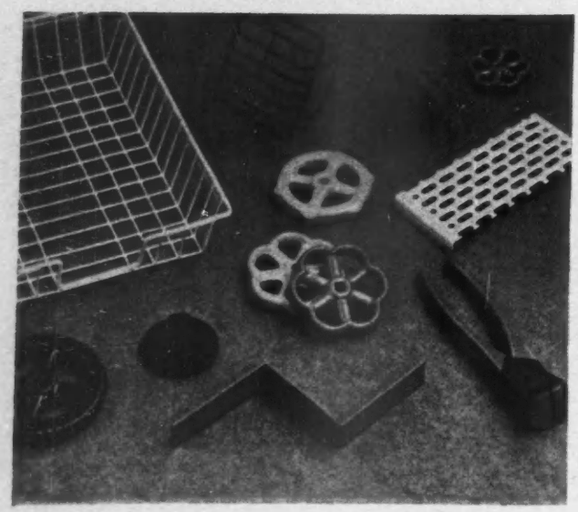
As with any coating system, the articles must be suspended. Marks left by wire used for this purpose are easily sealed with a hot air gun or with a sealing compound.

By this method, coatings up to 0·050 in thick can be applied in one dip. Minimum thickness is determined by flow characteristics of the plastic. If less than 0·010 in, a rough surface will often result. Around corners, coatings are quite uniform, but it is advisable to keep radii above $\frac{1}{8}$ in to avoid cracking which happens because the thermal contraction of plastics is much greater than that of metal substrates. This implies that the adhesion is not very high, and regrettably this is true. For encasing, especially of small items, this does not matter, but for large surfaces subject to impact damage there will have to be some improvement. Preliminary work is being done on priming and precoating with adhesives, but at the moment, Telcon just recommend that surfaces should be thoroughly degreased and roughened. A sand-blasted or rust-pitted surface is ideal.

Plastics which are amenable to the process are shown in the table. Nylon, polypropylene and epoxies are in the development stage by Telcon, and an American firm reports success with the chlorinated polyether, Penton. The top temperature will be increased by application of thermosetting resins, which will of course have to be in a partly uncured form as powder so that they will melt and adhere.

The greatest use of this coating method has been for wire products, especially for the domestic market, but this is only the beginning. Some of the industrial applications are included below and many of them deserve careful consideration. Also, in the illustration are shown some of the established outlets; low density polyethylene for wire trays and air inlet guards; cellulose acetate butyrate for hand wheels; pvc for electrical insulation, and high density polyethylene for wear resistant protection and insulation.

How about using the process for coating pipe fittings for use with plastics pipe; stirring and fan impellers; aerial insulators; electroplating jigs; or cable trays and tool handles? Finally—cost: at present plastisol coating is a slightly cheaper process arising from lower material costs but the difference is quickly disappearing. Also, look at the other savings.



	Approximate melting point, °C	Safe temperature in use, °C	Article preheat temperature, °C	Fusion temperature, °C, and comments	Coating characteristics
Cellulose acetate butyrate	200	100	320—370	Maximum 200 for short periods only	Hard mirror finish. Tough and weather resistant
Low density polyethylene	110	65	150—300	Maximum 200	Smooth, moisture resistant
High density polyethylene	130	80	160—300	Maximum 200	Surfaces not smooth
Pvc	150	55	250—350	Not recommended	Properties vary with formulation from hard and tough to soft and resilient
Nylon 66	265	80	Up to 400	Avoid. Or short time at preheat temperature	Abrasion resistant and tough. Costs more than those above
Polypropylene	Similar to high-density polyethylene, but withstands temperatures up to 100° C				
Epoxy	Hard, tough and resistant to temperatures up to about 150° C, but very expensive				

Plastic Dough for Power Rammer

The illustration below is an upside down view of a power rammer foot. This striking component withstands forces of 8,000 lb as the rammer descends from its average magnificent jumps of 21 in. Pegson are the people who make the rammer, and Cascelloid the moulders of the Rockite dough moulding compound made by British Resin Products.

This dough moulding material is a fibre-and-mineral filled plastic which has good abrasion resistance, will withstand bacteriological attack and is unaffected by extremes of temperature. To comply with weight specifications, cavities

were moulded in the foot. Even as it is, it weighs nearly 14 lb and is said to be the largest dough moulding in the country. May it enjoy long life.
British Resin Products Limited, Devonshire House, Piccadilly, London, W1.

Continuously Cast Bronze Bearings

Replacement of sand cast bronze bushings by continuously cast bronze has recently solved a problem in 7,000 h.p. diesel engines manufactured by Enterprise Engine and Machinery Company of San Francisco.

In test runs and in field use, the bushings occasionally collapsed. These were made of SAE 660 sand cast bronze. Investigation of the collapsed bushings revealed that they had absorbed considerable quantities of oil which was clear evidence of porosity in the metal. Substitution of continuously cast metal has resulted in two years of complete freedom from bushing failure, with not one instance of seizure or scoring.

Comparative properties of SAE 660 bronze as cast by Asarco are shown below:

	Continuously cast	Permanent mould	Sand cast
Tensile strength, lb per sq. in	44,000	41,600	40,400
Yield strength, lb per sq. in	27,000	21,900	19,500
Elongation on 2 in, per cent	16	18	39
Reduction of area, per cent	14	18	28
Brinell hardness	72	69	65

The Enterprise design utilises an articulated pair of connected rods—a link rod that bears on a master rod which in turn bears on a single crankpin. Continuously cast bronze is used in the engines' connected rod wrist-pin bushings as well as for fuel, intake, and exhaust tappet rollers. The bushings are required to withstand maximum loads as tabulated in the next column.

Connecting rod bushings, 360 r.p.m. at 138 BMEP	2,375 lb per sq. in
Cam roller bushings, 360 r.p.m., at 138 BMEP	
Fuel	5,975 lb per sq. in
Exhaust	2,080 lb per sq. in
Intake	800 lb per sq. in

In the continuous casting process used by Asarco, molten metal, maintained at a uniform temperature, flows by gravity feed into self lubricating, water-cooled graphite dies where the metal solidifies. Guide wheels, mounted below, withdraw the cast product continuously at a controlled speed. The furnace, totally enclosed in a steel shell, operates in a nitrogen atmosphere that serves to carry away porosity producing gases. This gravity fed bottom-flow casting method precludes the possibility of trapping incidental dirt and dross. Foreign matter floats to the top of the melt without turbulence to carry it into the casting die. Freezing from the bottom upward permits the escape of dissolved gases liberated during solidification.
Enterprise Engine and Machinery Company, San Francisco, California, USA.

Gloves— Novel and Standard

Look after your hands . . .

Oil and solvent resistant gloves for delicate work have recently been introduced by Fireproof Tanks. Based on Hycar nitrile rubber made by British Geon, these thin yet strong gloves are particularly useful for work involving the use of solvents such as the polyester hand lay-up process.

A few months ago, James North and Sons introduced another new kind of glove. Called North Jomac, the gloves are made of hard wearing loop-pile fabric with insulating properties against heat or extreme cold described as "unusual," as well as being very resistant to abrasion. This line has now been enlarged and expanded to cover mitts and sleeves and the entire range is described in a new leaflet.

Rubber gloves for electrical purposes are the subject of a revised British Standard 697: 1960. This publication specifies requirements for gloves for use at four different voltage levels: up to 650, 1,100, 3,300, and 4,000 volts. Gloves may be made by a dipping process, built up from sheet rubber, or by a moulding process.

A feature of this revised standard is that each glove is now required to be tested twice by the manufacturer for its voltage resistance. The second test has been introduced to seek out those gloves which have a tendency to pick up excess moisture, which reduces dielectric strength. Research into this phenomenon has been carried out by the Electrical Research Association, who took an active part in the redrafting of the standard. (Price 5*s*).
Fireproof Tanks Limited, The Airport, Portsmouth.
James North and Sons Limited, Kirkman House, Tottenham Court Road, London, W1.
British Standards Institution, 2 Park Street, London, W1.

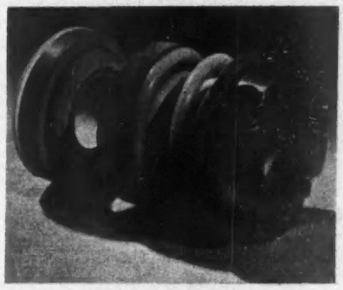
New Fluxes Improve Welding and Brazing

Battelle workers have come up with a welding flux which improves the ductility of submerged arc welds in high strength steel plate as used for submarine hulls. This is less acid than ones now in use and contains little silica but a large amount of calcium oxide. Using the new flux and commercial grade wire, welds have been made in HY-80 structural steel with yield strengths of about 90,000 lb per sq. in, ultimate strengths of 100,000, excellent tensile ductility, and notch impact values of 30 ft-lb at − 100° F. Prior to the development of this flux welds with comparable yield and ultimate strengths had values of only 10 to 15 ft-lb at that temperature. The low values arose mainly from high oxygen contents and numerous silicate inclusions in submerged arc welds in this alloy.

Another dry vapourising flux developed by Wall Colmonoy disrupts the tenacious oxide films formed on alloys containing aluminium and titanium and is also said to be of value where the atmosphere is of dubious quality, for example hydrogen with a high dew point. The new fluxes are now incorporated in a line of self-fluxing brazing alloys for high temperature service applications.
Battelle Memorial Institute, Columbus 1, Ohio, USA.
Wall Colmonoy (Canada) Limited, 68A Wigmore Street, London, W1.

Ptfe Seal Lasts 17,500 Hours in Acid

In October, 1956, Crane Packing introduced a type of mechanical seal for use on services handling highly corrosive acids and chemicals.



This was the Fluoseal, whose working surfaces are almost wholly pure or glass-filled ptfe. One of these seals has recently been taken out of service after a life of 17,500 hours on an application involving sealing against a 70 per cent solution of sulphuric acid.

The makers say that this exceptional life would not normally be anticipated under conditions such as this. The seal was in fact put into service on a LaBour pump at the Newport factory of the National Smelting Company. It was installed in November, 1956 and was not taken out of service till December, 1959. During the period of service the pump was started and stopped approximately 20,000 times; the maximum temperature encountered was 125° F and the shaft speed was 1,750 r.p.m.

When the seal was taken out of service there was some degree of wear on the seal faces, but the general condition of the seal can be seen from the illustration.
Crane Packing Limited, Slough, Bucks.

Nb-Steels Stand Subzero Welding

National Steel Corporation has launched a family of high strength, fine grained, semikilled mild carbon steels in the USA. Known as GLX-W steels, they contain niobium. A typical composition is 0·016 C-0·18 S-0·05 Si-0·75 Mn-0·009 P-0·04 Nb-steel but the niobium content can be lower than this.

Chemical composition is therefore approximately the same as for mild carbon steels in the 30,000-40,000 lb per sq. in yield range. In the GLX-W alloys the strength is guaranteed at four levels of 45,000; 50,000; 55,000 and 60,000 lb per sq. in yield strength.

The outstanding feature of the steels is their weldability for cold weather pipeline installation. The alternative alloys are carbon-manganese-steels, but, as National Steel comment, even despite the control over preheating and cooling which must be carried out when the temperature falls below 40° F, the results are often not good. The 45,000 lb per sq. in grade has already been fabricated into five miles of 24 in diameter pipe and installed into a high pressure natural gas line in Texas. This has been in service since September, 1959, without incident.
National Steel Corporation, Pittsburgh 19, Pa, USA.

Plain Words

By Capricorn

IT is often said that the man on the shop floor is at a disadvantage because he is out of touch with the policies and plans of his firm. Managers should therefore watch that as far as possible full information is given to the men in good time, so that their willing cooperation is ensured.

I would like to turn that particular penny round and look at its other side. In all but the very smallest organisations, the manager is himself at a serious disadvantage because he is out of touch with the decisions and actions which others take without his knowledge. If he is one of the worrying type he probably loses a lot of sleep wondering whether something is going on without his knowledge which may have serious repercussions.

It was Lord Montgomery—then General Sir Bernard—who first publicly stressed the need to keep the troops fully informed. There had, of course, been plenty of soldiers and industrial leaders who had been aware of the fundamental importance of such a policy, but I think it was Monty who appreciated the publicity and confidence-creating value of not only keeping everyone fully informed but—and this was his innovation—of telling everyone that it was his practice to keep everyone informed.

Since then it has been common, though not universal, practice to follow the basic principle which achieved such success nearly twenty years ago. But what of the leader himself?

Montgomery, as far as I know, never complained that the commander of an army suffers agonies of doubt and apprehension lest the folly or unimaginativeness of a subordinate might lose the battle. As commander, he had the greatest cause to worry over the outcome of the engagement. Yet, as is well known, he went to bed early on the night of the battle and got plenty of sleep in case he was needed for a long spell later.

Whether as a soldier or in industry, a man with responsibility must acquire the philosophy which allows him to be intensely concerned to see that every detail is taken care of, yet supremely indifferent to detail itself. It is difficult for a soldier to acquire this outlook because he may reach high rank without the benefit of operational experience in war. The man in industry is more fortunate. He has the opportunity to graduate at each level of responsibility. If the organisation expands while he is serving it he also has the good fortune to develop that rare quality—a progressive increase in personal detachment. Lord Reith describes this well in his autobiography; as the BBC expanded from a little office without even a name plate on it, he adhered to his basic maxim—never to have more than about six others directly responsible to him.

The man at the top cannot know about everything that is going on. He must just grin and bear it.

Letters to the Editor

An Energetic Outlook in the North East

SIR, I have read with interest Mr. H. J. Novy's article on "Engineering Growth in the North East of England" (ENGNG., 8 April '60, p. 478).

There appears to be a tendency to be obsessed by the unemployment percentages in different parts of the country, and because it is one per cent higher in one area than another, that special consideration should be given in the direction of industry to that particular district.

My own view is that it would be much more useful, particularly in the case of the North East, to emphasise the progressive energetic outlook which is characteristic of the area, which has found since the war expression in a variety of directions, outstanding even when the whole of the country is reviewed.

I would like to see the North East base its claim as a desirable area to which new enterprises could be attracted on the qualities I have already mentioned, plus the excellent public services, road rail and sea transport; water, gas and electricity services, and, most important, the high quality of labour in the area and its excellent record of comparative freedom from strikes and unofficial stoppages.

Yours sincerely,
W. G. WILLIS.

Saltburn-by-the-Sea,
Yorkshire.
22 April, 1960.

Thermodynamic Theory

SIR, I read with interest Mr. William Drummond's review of *Foundations of Thermodynamics with Antitheses and Disputation* (ENGNG., 20 Nov. '59, p. 514) by Mr. Sven Svantesson, and the author's subsequent letter (ENGNG., 11 Mar. '60, p. 345). I have since seen the book and should like to comment.

Mr. Svantesson criticises the blind acceptance of the Second Law of Thermodynamics and states (page 10) that according to the classical laws "Theoretically, granted an indefinitely large heat reservoir, work may indefinitely be produced regardless of the temperature of the reservoir." Similar statements appear on pp. 48 and 54, and a footnote on p. 49 indicates that a device for doing this has been patented.

In principle, such a device is described on p. 48 and, as I understand it, may be shown diagrammatically as in the accompanying Fig. 1.

Mr. Svantesson does not make it clear whether his "intermediate reservoir" at T_1' is finite or infinitely large. The device, however, cannot operate continuously unless it is infinite. It is easily shown that the net output from the combined engine-refrigerator

$$W_{net} = Q_1\left(\frac{T_1 - T_1'}{T_1}\right)$$

and, as one would expect, it is equivalent to a Carnot cycle working between T_1 and T_1'. The finite sink at T_2 has no influence on the result.

As far as I can ascertain, Mr. Svantesson seriously proposes such a device as a contravention of the Second Law and suggests that it will produce work continuously irrespective of the value of T_1'. These statements are serious lapses in what otherwise appears to be a thoughtful work. It is true that the basic laws of classical thermodynamics are at the present time undergoing a reappraisal, not as to their validity but to find more economic and general statements. Mr. Drummond pointed out that the work of Carathéodory is notable in this respect.

There is no doubt that the limitation of the law $dQ = T\,dS$ to reversible processes is a serious one but recent work (such as Prigogine, *The Thermodynamics of Irreversible Processes*, Blackwell, 1955) has shown that it can be extended to irreversible processes by starting from a closed system such as shown in Fig. 2. In such a device dQ_f is mechanical work which is taken from the piston and returned into the fluid by stirring. This energy supply is, of course, equivalent to a heat transfer, but it can only occur in one direction, i.e. stirring energy can be put into the fluid but not taken out.

For the closed system shown, assuming that dynamic effects are absent, i.e., quasi-static equilibrium

$$dW_R = dW + dQ_f = p\,dv$$

Also
$$dQ = dE + dW$$
$$= dE + p\,dv - dQ_f$$

or
$$dQ + dQ_f = dH - v\,dp$$
$$(H = \text{enthalpy})$$

But by accepted methods we can show that

$$dH - v\,dp = T\,dS$$

since this involves state functions only.

Hence

$$dQ + dQ_f = T\,dS$$

and the way is now open to determine directly entropy changes for irreversible processes.

As an example, consider the expansion of the fluid in the adiabatic vessel in Fig. 3 which proceeds by the successive bursting of diaphragms. This process is totally irreversible.

Since $dW = 0$
we have $dW_R = dQ_f = p\,dv$
Since $dQ = 0$
$T\,dS = dQ_f = p\,dv$
and thus $dE = 0$

Hence
$$S_2 - S_1 = \int_1^2 \frac{p}{T}\,dv$$

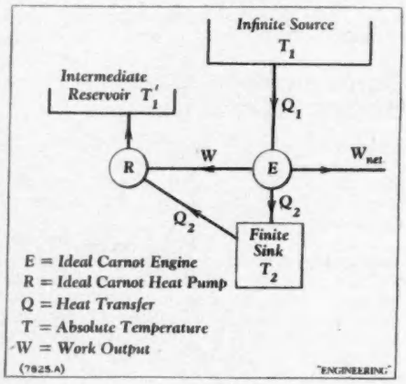


Fig. 1

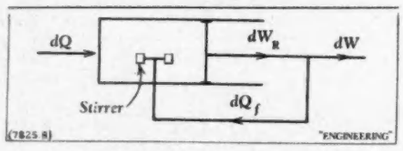


Fig. 2

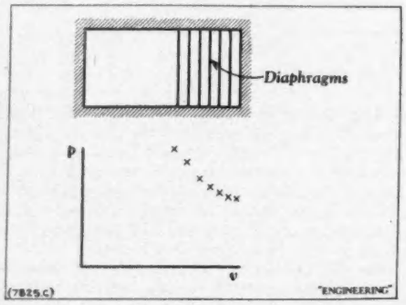


Fig. 3

Should the fluid obey $pv = RT$, the well known result is obtained

$$S_2 - S_1 = R \log \frac{v_2}{v_1}$$

Previously this result has been obtained by substituting a reversible path with heat ransfer.

This approach can easily be applied to open systems and has also been recently applied to the theory of coupled flows and the thermocouple relations derived by Prigogine and others.

I hope that Mr. Sven Svantesson's book will stimulate further inquiry into the classical laws but I cannot feel that he has in any way disturbed their validity.

Yours faithfully,
A. P. HATTON,
Lecturer in Mechanical Engineering.

Manchester College of Science and Technology,
Sackville Street, Manchester 1.

14 April, 1960.

Educating the Engineer

SIR, We should like to comment on the discussions of problems in scientific education contained in recent issues of your journal (ENGNG., 27 Nov., 4 Dec. and 18 Dec. '59, pp. 526, 566 and 629). In point of economy in effort and time, we share with Capricorn the view that "Science teaching is in a bad way."

The exponential increase of information in each branch of science poses enormous problems even for the specialist in each branch; it is commonplace for him to respond by further narrowing his range of competency. Such a solution is not as readily available to those in the professions of engineering and medicine, where to be competent specialists in a particular realm of application requires the comprehension of current information from diverse branches of science. Sooner or later, this problem must be faced in a substantial way.

The discussion in your journal tends to establish an artificial dichotomy between "informal experience" or phenomenon on the one hand, and concept or theory on the other. All proper science is inseparable from meticulous observation; at the same time, almost no fruitful observations of phenomena proceed without the benefit of interpretation (theory). The problem for education in science at all levels is not to choose between phenomenon and theory, but to build knowledge of the former and understanding of the latter in a way which develops along with, and further stimulates, the student's power to deal with concepts. It is the teacher's duty to place phenomenon beside interpretation, the suggestion of theory against fact, in such a skilful fashion that students save themselves at least a portion of the struggle of past innovators in order that they may have the power (and time) to innovate in their turn.

It is a common, albeit astonishing, view that certain (generally recent) basic ideas are intrinsically too difficult for young minds to grasp. What one must face is that teachers, in the absence of a number of hours for contemplation commensurate with the number of hours they must teach, tend to teach as they were taught, and to regard as difficult and esoteric what their own masters regarded in that way. The teacher who says to a student: "You must work for many years yet (on mathematics, for example) in order to understand that point" would in general speak more precisely if he said: "I am sorry, *I* do not understand that point in a simple way."

Surely it is inconceivable that mathematics should be regarded as a drag on the science curriculum. If science masters need certain mathematical ideas which their students have not yet met, they should teach these ideas in the context of their utility for the science, explaining clearly that they are not teaching mathematics in the sense of an abstract and self-consistent set of relations. That these ideas should also be taught in a formal mathematics course which stresses internal rigour and consistency goes without saying. What is not clear is that this formal presentation need be the only, or even the first, that the student receives.

The explosive development of science, particularly in this century, has an aspect which may seem to your readers to be included here for parochial reasons, but which we believe to be correct and of vital importance. A part of the extraordinary accomplishment in science has been a change in the relation of traditional sciences to each other. Physics, chemistry and biology, for example, are not independent parallel sciences of clearly distinguishable phenomena. In part, the distinction between these sciences lies in the intrinsic complication of the systems which concern them rather than in a profound separation of the concepts which each science uses. While there are general features associated with the complex systems of chemistry and biology which may be used to provide understanding of even more complex systems, it presently seems to be so that these general features must themselves be regarded as explicable in terms of a large number of elementary particles interacting in accordance with a few laws. As a consequence, the relation of physics to other sciences is a partially serial one.

It therefore appears to be a matter of enormous importance to all the sciences, as well as to engineering and medicine, that the traditional quasi-historical introduction to physical ideas be reconstructed in the light of the general significance of these ideas to other sciences and to technology. Our basic assumption is that there is not one kind of introductory physics for engineering students, another kind of physics for students going into medicine, and yet another kind for those who will elect pure science. There is a common need for a rigourous introductory course in the physical ideas of 1960 which may be used as a starting point for careful thought in any one of many possible directions. The course which we present to our Freshmen students we believe to be unique, but if it were merely different, we should not feel so strongly that such an approach warrants consideration by all those who have a professional interest in scientific education. We regard this course as a serious attempt to cut through the enormous developments in the understanding of the physical universe in such a way that the student may begin to make his own contributions sooner. That there are difficulties and inadequacies in what we are doing is very clear to us, but we are convinced that in the long run, this is the direction in which science education must go.

Yours truly,
E. D. LAMBE,
Assistant Professor of Physics.

J. M. FOWLER,
Assistant Professor of Physics.

Washington University,
St. Louis 30, Missouri, USA.

12 April, 1960.

Training African Engineers

SIR, May I crave your indulgence in allowing me to add a factual supplement to the information given in your article "Engineering Training in the New Nations," by Mr. J. B. Hunt (ENGNG., 26 Feb. '60, p. 287), and Dr. C. A. Hart's letter (ENGNG., 11 Mar. '60, p. 344), as far as the Kumasi College of Technology is concerned?

The School of Engineering—civil, electrical and mechanical departments—is a "recognised" school by the University of London and by the Institutions of Civil, Mechanical and Electrical Engineers for the preparation of students for the B.Sc. (Eng.) external degree and graduate membership, respectively. In 1959, the first three graduates were awarded their B.Sc. degree, three their G.I.C.E. and two G.I.M.E. Our expectations in future years are: B.Sc.(Eng.), London, over 10 in 1960; 15 in 1961; 25 in 1962; and thence 30 per year apart from Institution graduates. In the land surveying section of the R.I.C.S. (London) the first candidates were presented in 1959 and out of the two who obtained their intermediate qualification one was awarded the Nixon prize, being the best candidate presented that year.

Yours sincerely,
C. LEVINE,
Director.

School of Engineering,
Kumasi College of Technology,
Kumasi, Ghana.

29 April, 1960.

Graduates of Nottingham

SIR, May we request the use of your correspondence columns to inform those among your readers, who are ex-engineering students of the University of Nottingham, of the existence of the recently formed Engineering Graduates' Association.

Membership of this Association is open to all engineers who graduated from either the University College or the University, and further particulars can be obtained from the undersigned.

Yours faithfully,
A. B. CLEARY
J. L. DOUGLAS
Joint Honorary Secretaries.

Mechanical Engineering Department,
University of Nottingham,
University Park, Nottingham.

6 April, 1960.

Events in Advance

Clothing Production Two Years Hence

LAST month's International Clothing Trade Exhibition at Olympia—the third of these biennial events—was attended with such a measure of success that the organisers have been enabled to arrange for the fourth exhibition in the series to be held at the same venue at some time between 9 and 20 April, 1962. Looking further ahead still, the organisers have secured tenancies at Olympia for periods in 1964 and 1966.

A number of inquiries regarding the next exhibition were made during the course of last month's display and, by the end of the event, over half this year's exhibitors are reported as having re-booked; many of them seeking additional space. Attendances last month, too, were considerably higher than at the previous function in 1958.

The clothing trade convention, which was the first of its kind to be organised in connection with these exhibitions, was generally welcomed and is likely to become a permanent feature. Papers to the convention were read by fashion experts, clothing production consultants, sales executives and specialists on packaging aspects. Much interest was developed in respect to a technical film from Germany which described Continental production methods in the outer clothing industry and it had to be screened on two occasions. Visitors from no fewer than 35 countries, embracing each of the five continents, came to see the exhibits or to take part in the convention.

Considerable strides forward are likely to be made during the next few years in regard to textile machinery of all kinds, the techniques of clothing production and the development of natural and artificial fibres, and these possi-

bilities give an increased importance to the exhibitions. The organisers are U.T.P. Exhibitions Limited, 9 Gough Square, Fleet Street, London, EC4. Telephone: FLEet Street 3172.

Exhibitions and Conferences

Mechanical Handling Exhibition and Materials Handling Convention.—Running from Tues., 3 May, to Fri., 13 May, at Earl's Court, London, SW5. Organised by *Mechanical Handling*, Associated Iliffe Press, Dorset House, Stamford Street, London, SE1. Tel. WATerloo 3333.

Grocers' and Allied Trades Exhibition.—Running from Tues., 3 May, to Sat., 14 May, at Belle Vue, Manchester. Offices: 393 Corn Exchange, Manchester 4. Tel. Blackfriars 4969.

Kemp's Television Production Exhibition.—Mon., 9 May, to Fri., 13 May, at Alexandra Palace, Wood Green, London, N22. Apply to the general manager, Kemp's Commercial Guides Ltd., 299-301 Gray's Inn Road, London, WC1. Tel. TERminus 0152.

Automobile Technical Congress, Eighth International—Mon., 9 May, to Fri., 13 May, at The Hague and Scheveningen, Netherlands. This is the congress of the Fédération Internationale des Sociétés d'Ingénieurs des Techniques de l'Autombile (FISITA). Organised by the Koninklijk Instituut van Ingenieurs. Congress offices: 14 Burgemeester de Monchyplein, The Hague, Netherlands.

British Rayon Research Association: Open Days.—Wed., Thurs. and Fri., 11, 12 and 13 May, at the Heald Green Laboratories, Wythenshawe, Manchester. Apply to the Information Officer at the Laboratories.

Arid Zone Problems, Symposium on.—Wed., 11 May, to Wed., 18 May, in Paris. Organised by UNESCO. Apply to M. Batisse, Arid Zone Unit, Natural Sciences Department, UNESCO, Place de Fontenoy, Paris 7e.

Royal Institution of Naval Architects, Centenary Meeting.—Mon., 16 May, to Fri., 20 May, in London. Institution offices: 10 Upper Belgrave Street, London, SW1. Tel. SLOane 4622.

Sheet Metal Forming, Especially Methods of Testing, Colloquium.—Mon., 23 May, to Wed., 25 May, in Paris. Organised jointly by Société Française de Métallurgie, 25 Rue de Clichy, Paris 9a, and the International Deep Drawing Research Group (IDDRG). Particulars obtainable from the British Deep Drawing Research Group, John Adam House, Adelphi, London, WC2. Tel. TRAfalgar 6171.

Self Service and Shop Equipment Exhibition.—Mon., 23 May, to Fri., 27 May, at Olympia, London, W14. Organised by Universal Exhibitions, Ltd., 74 Holland Park, London, W11. Tel. PARk 7360.

Medical Exhibition.—Mon., 23 May, to Fri., 27 May, at St. Andrew's Hall, Glasgow. Organised by B and C D Trades Exhibitions Ltd., 194-200 Bishopsgate, London, EC2. Tel. AVEnue 1444.

Instruments, Electronics and Automation, International Exhibition.—Mon., 23 May, to Sat., 28 May, at Olympia, London, W14. Organised by Industrial Exhibitions Ltd., 9 Argyll Street, London, W1. Tel. GERrard 1622.

Small Craft for Fisheries and Transportation Work, First International Economic Conference on.—Tues., 24 May, at the Hotel Waldorf-Astoria, New York. Sponsored by Outboard Marine International S.A., Nassau, Bahamas, and their parent organisation, the Outboard Marine Corporation, Waukegan, Ill., USA.

Royal Ulster Agricultural Show, 93rd.—Wed., 25 May, to Sat., 30 May, at the King's Hall, Belfast. Organised by the Royal Ulster Agricultural Society, King's Hall, Balmoral, Belfast.

Bath and West Agricultural Show.—Wed., 1 June, to Sat., 4 June, at the Show Site, Bath. Organised by the Bath and West and Southern Counties Agricultural Society, 3 Pirrepoint Street, Bath. Tel. Bath 3010.

Building and Public Works Exhibition.—Sun., 12 June, to Sat., 25 June, at Durham County Show Ground, Lambton Castle, Chester-le-Street. Sponsored by the Northern Counties Regional Federation of Building Trades Employers, 15 Norfolk Street, Sunderland. Tel. Sunderland 5288.

Three Counties Agricultural Show.—Tues., 14 June, to Thurs., 16 June, at the Show Site, Malvern. Organised by the Three Counties Agricultural Society, Malvern, Worcs. Tel. Malvern 2231.

Large Electric Systems, International Conference on.—Wed., 15 June, to Sat., 25 June, at the Foundation Berthelot, 28 Rue Saint Dominique, Paris. Organised by the Conférence Internationale des Grands Reseaux Électriques (CIGRÉ), 112 Boulevard Haussmann, Paris. Apply to the British National Committee, Thorncroft Manor, Dorking Road, Leatherhead, Surrey. Tel. Leatherhead 3423.

Nuclear and Electronic Congress and Exhibition, Seventh.—Wed., 15 June, to Wed., 29 June, in Rome. Agents: Auger and Turner Group Ltd., 37-38 Margaret Street, Cavendish Square, London, W1. Tel. HYDe Park 7282.

Great Yorkshire Agricultural Show.—Tues., 12 July to Thurs., 14 July, at the Show Ground, Harrogate. Organised by the Yorkshire Agricultural Society, Cliftonfield, Shipton Road, York. Tel. York 23102.

Sydney Engineering Exhibition.—Mon., 18 July, to Sat., 23 July, at the Showground, Sydney. Apply to Industrial Public Relations Service (NSW), Pty., Ltd., Box 4962, GPO, Sydney, New South Wales.

Royal Society's Tercentenary Celebrations.—Mon., 18 July, to Tues., 26 July, in London. Offices of the Society: Burlington House, Piccadilly, London, W1. Tel. REGent 3335.

Royal Welsh Agricultural Society Show.—Wed., 20 July, to Fri., 22 July, at Welshpool. Apply to the Royal Welsh Agricultural Society, Queens Road, Aberystwyth. Tel. Aberystwyth 7551.

Medical Electronics, International Scientific Exhibition and Third International Conference.—Thurs., 21 July, to Wed., 27 July, at Olympia, London, W14. Sponsored in association with the International Federation for Medical Electronics by the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, WC2. Tel. COVent Garden 1871. Exhibition organised by Industrial Exhibitions Ltd., 9 Argyll Street, W1. Tel. GERrard 1622. (Additional information).

British Association Meeting.—Wed., 31 Aug., to Wed., 7 Sept., at Cardiff. Apply to the secretary, British Association for the Advancement of Science, 18 Adam Street, Adelphi, London, WC2. Tel. TRAfalgar 5733.

British Food Fair, Sixth.—Thurs., 1 Sept., to Sat., 17 Sept., at Olympia, London, W14. Organised by the Food Manufacturers Federation, 10 Mount Row, London, W1. Tel. HYDe Park 2933.

Operational Research, Second International Conference on.—Mon., 5 Sept., to Fri., 16 Sept., in Aix-en-Provence, France. Organised by the International Federation of Operational Research Societies (IFORS), 11 Park Lane, London, W1.

Meetings and Papers

Association of Supervising Electrical Engineers

BIRMINGHAM
"Industrial Lighting," by R. J. F. Howard. Birmingham Branch. Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham 2. Wed., 11 May, 7.30 p.m.

WEMBLEY
"Miniature Circuit Breakers," by R. Leach. North West London Branch. The Century Hotel, Wembley. Mon., 9 May, 8.15 p.m.

Combustion Engineering Association

READING
"Ability of Mechanical Stokers to Comply with Section I of the Clean Air Act:" Discussion. Southern Region. Great Western Hotel, Station Road, Reading. Wed., 11 May, 10.30 a.m. (Change of date.)

Illuminating Engineering Society

LEEDS
Annual General Meeting. Leeds Centre, Guildhall Hotel, The Headrow, Leeds. Mon., 9 May, 6.15 p.m.

Institute of Marine Engineers and Royal Institution of Naval Architects

LONDON
"The Occurrence of Explosive Gas in the Cargo Tanks of Crude Oil Carriers," by A. Logan and Dr. J. W. Drinkwater. Joint Meeting. Institute of Marine Engineers, 76 Mark Lane, EC3. Tues., 10 May, 5.30 p.m.*

Institute of Petroleum

LONDON
"Petroleum People: Planning for Tomorrow": Presidential Address, by C. M. Vignoles. Wed., 11 May, 6 p.m.*

Institute of Physics

LIVERPOOL
"The Physics of Glaciers," by Dr. J. W. Glen. Annual General Meeting. Liverpool and North Wales Branch. The University, Liverpool. Thurs., 12 May, 7 p.m.

Institute of Road Transport Engineers

CARDIFF
"Cummins Diesels": a series of instructional films exhibited by Cummins Diesel Sales and Service Ltd. South Wales Centre. South Wales Institute of Engineers, Park Place, Cardiff. Fri., 13 May, 7.15 p.m.

Institution of Civil Engineers

LONDON
"Port of London Authority: Development of Two Dock Areas, 1959," by D. E. Glover, E. Newton, H. M. Dale and T. R. Brown. Tues., 17 May, 5.30 p.m.*

Institution of Electrical Engineers

LONDON
"Development of the 400 kV Network in Sweden," by G. Jancke. Annual Lecture. Supply Section. Wed., 11 May, 5.30 p.m.*
"Resistance of Sheet Insulation to Surface Discharges," by Dr. J. H. Mason. Thurs., 12 May, 5.30 p.m.*

BIRMINGHAM
"Radio Aspects of the International Geophysical Year," by Dr. R. L. Smith-Rose. South Midland Centre. College of Technology, Gosta Green, Birmingham. Mon., 9 May, 6.30 p.m.*

STAFFORD
"The Characteristics and Protection of Semiconductor Rectifiers," by D. B. Corbyn and N. L. Potter. Annual General Meeting. North Staffordshire Subcentre. Technical College, Stafford. Mon., 16 May, 7 p.m.*

Institution of Mechanical Engineers

LONDON
"The Automobile of the Far Future," by A. A. Kucher. Automobile Division. Wed., 18 May, 6 p.m.*

Institution of Plant Engineers

GLASGOW
"Industrial Television and Its Applications," by S. G. Gobbi. Glasgow Branch. Scottish Building Centre, 425-427 Sauchiehall Street, Glasgow. Thurs., 12 May, 7.15 p.m.

MANCHESTER
"The Application of New Materials to Plant Engineering," by J. Leyland. Manchester Branch. Engineers' Club, Albert Square, Manchester. Tues., 10 May, 7.15 p.m.

NEWCASTLE UPON TYNE
"Science and Industry," by E. Martindale. North East Branch. Roadway House, Oxford Street, Newcastle upon Tyne. Thurs., 12 May, 7 p.m.

Physical Society

TEDDINGTON
"Fourier Transform Spectroscopy," by Dr. H. A. Gebbie; and "Spectropolaimetry," by J. W. Gates and Dr. J. R. King, at 11.15 a.m. "Refractometry of Optical Glasses," by K. J. Habell and A. Jackson, at 2.30 p.m. Demonstrations in basic physics and light divisions, at 4 p.m. Optical Group. The National Physical Laboratory, Teddington, Middlesex. Thurs., 12 May.

Royal Aeronautical Society

LONDON
"On Reducing Costs of Space Research," by J. E. Allen. Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, SW1. Thurs., 12 May, 6 p.m.*

Royal Institution

LONDON
"Are the Laws of Nature Symmetrical?" by Professor O. R. Frisch. Fri., 11 May, 9 p.m.

Royal Society

LONDON
"An Analysis of Rock Magnetic Data," by P. M. S. Blackett, J. A. Clegg and P. H. S. Stubbs; and "The Origin of the Solar System," by W. H. McCrea. Thurs., 12 May, 4.30 p.m.*

Royal Society of Arts

LONDON
"The Generation of Power," by Professor J. M. Kay. First of three Cantor Lectures on "Energy." Mon., 9 May, 6 p.m.

Society of Instrument Technology

LONDON
"A Recording Stereocomparator," by A. E. Adams. Annual General Meeting. Data Processing Section. Manson House, 26 Portland Place, W1. Wed., 11 May, 7 p.m.*

LIVERPOOL
Annual General Meeting and Film Evening. Liverpool Section. Industrial Development Centre, Manchester and North Western Electricity Board, Paradise Street, Liverpool. Thurs., 12 May, 7.15 p.m.

MANCHESTER
"Instruments in Pharmaceutical Research," by Dr. J. W. Black. Manchester Section. Central Library, St. Peter's Square, Manchester 1. Tues., 10 May, 6.45 p.m.

South Wales Institute of Engineers

CARDIFF
"The Aberthaw Power Station," by W. Wilde. Thurs., 19 May, 6 p.m.

Television Society

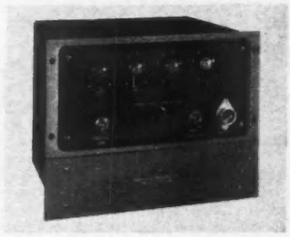
LONDON
"The Status of Storage Tubes in America," by Dr. R. R. Law. Cinematograph Exhibitors' Association, 164 Shaftesbury Avenue, WC2. Fri., 13 May, 7 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. An asterisk (*) is placed where it is understood that refreshments are available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury Square, London, WC1. (LANgham 5927)
Combustion Engineering Association, 70 Jermyn Street, St. James's, London, SW1. (WHItehall 5536)
Illuminating Engineering Society, 32 Victoria Street, London, SW1. (ABBey 5215)
Institute of Marine Engineers, Memorial Building, 76 Mark Lane, London, EC3. (ROYal 8493)
Institute of Petroleum, 61 New Cavendish Street, London, W1. (LANgham 3583)
Institute of Physics, 47 Belgrave Square, London, SW1. (BELgravia 6111)
Institute of Road Transport Engineers, 69 Victoria Street, London, SW1. (ABBey 6248)
Institution of Civil Engineers, Great George Street, London, SW1. (WHItehall 4577)
Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, WC7. (COVent Garden 1871)
Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, London, SW1. (WHItehall 7476)
Institution of Plant Engineers, 2 Grosvenor Gardens, London, SW1. (SLOane 0469)
Physical Society, 1 Lowther Gardens, South Kensington, London, SW7. (KENsington 0048)
Royal Aeronautical Society, 4 Hamilton Place, London, W1. (GROsvenor 3515)
Royal Institution, 21 Albemarle Street, London, W1. (HYDe Park 0669)
Royal Institution of Naval Architects, 10 Upper Belgrave Street, London, SW1. (SLOane 4622)
Royal Society, Burlington House, Piccadilly, London, W1. (REGent 3335)
Royal Society of Arts, John Adam Street, Adelphi, London, WC2. (TRAfalgar 2366)
Society of Instrument Technology, 20 Queen Anne Street, London, W1. (LANgham 4251)
South Wales Institute of Engineers, Park Place, Cardiff. (Cardiff 23296)
Television Society, 166 Shaftesbury Avenue, London, WC2. (TEMple Bar 3330)

TACHOMETER

Decade Counters



FOUR and five stage dekatron tachometers can now be supplied to suit a large number of applications.

The appearance has been designed for cleanness of line for display purposes, Up to ten timing periods can be provided for and there is accommodation for several input signals. Selection is made by a rotary switch which can be engraved to suit the particular requirements. Front or rear mounted sockets and a variety of input circuits can be provided according to the application. It is claimed that this design allowing for special modifications is cheaper than building up from standard sub-units to obtain the required instrument. It is also claimed that the resultant front panel layout is inherently cleaner and neater.

The example illustrated is modified to measure the shaft speed of an alternator by counting the generator electrical output of 15 cycles per revolution for an accurate 4 second period. The readings are repetitive and after a 2 sec hold period for display the dekatrons reset and the next count is made. The display can be held by a switch on the front panel which can be operated at any time during the counting or display process.

The circuitry has been simplified to use only 12 valves and 3 selenium diodes in addition to the dekatrons; as a result the size has been kept compact. Overall measurements are 9¼ in by 7¼ in by 7½ in deep. When removed from the case the three sub units, which are hinged, can be opened out for easy access to all components. High quality valves and high stability resistors are used to give reliability. *Pentechnique Limited, Imperial Lane, Cheltenham, Glos.*

DOCUMENT COPIER

Fully Automatic

THE Xerox 914 is a machine for copying documents using automatic xerography.

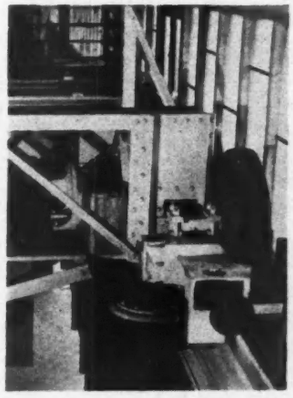
The copies are made on standard paper and the colour of the original is not important. Pen, pencil or ink stamp all reproduce. Multiple copies can be made of the same item by dialling the number required (" continuous " if more than 15 are wanted) and pushing the start button. Neither the original nor the copy paper is handled during the process. There is no setting of exposure times and all materials are dry.

To operate, the document is placed face downwards on the scanning glass; the maximum size permissible is 9 in by 14 in. The cover is closed and the required number set on the dial. Copy paper sizes can range from 8 in by 5½ in to 10 in by 15½ in and up to six prints per minute can be produced. The stock capacity is approximately 200 sheets.

The machine is available on hire only (in this country) at a monthly rental with an additional charge for each copy above 2,000 made during the month. It is not intended for casual use but for the larger concern where large numbers of copies make it a paying proposition. Overall dimensions of the machine are 45 in long by 46 in wide by 31 in high (42 in to top of control panel). The weight is 640 lb. Power supply required is 240 V a.c. 50 cycles, the consumption being approximately 2,000 watts. *Rank-Xerox Limited, 33-41 Mortimer Street, London, W1.*

OVERHEAD CRANE

With Pneumatic Tyres



RECENTLY commissioned in one of the Reed Group paper mills are two overhead travelling cranes running on pneumatic rubber tyres.

The idea was developed by W. S. Atkins and Partners to meet the intense operating conditions of the mills. The use of pneumatic tyres would allow the construction of the cranes to be generally lighter as the impact problems of steel wheels have been eliminated, though conventional design has been maintained. The track is of concrete.

Each end carriage is supported on five pneumatic tyred wheels using Michelin X 7·00-20 size, together with two horizontally mounted solid André rubber tyred wheels that bear on the sides of the concrete runways to keep the cranes on a straight path. Disc brakes are fitted to two of the wheels of each assembly and a 7·5 h.p. electric motor drives one other wheel through reduction gearing. The nominal span and load are 69 ft 6 in and 3 tons.

Experiments have shown that vertical steps of 1½ in in the track made no difference and a lateral displacement of one support column relative to the next of 4 in could be tolerated. Traverse speeds were increased to 360 ft per minute with a possible maximum of 400 ft per minute. *Strachan and Henshaw Limited, Whitehall, Bristol 5.*

LOADER

Pry-Out Force 7,400 lb

THREE new machines have been added to the Muir Hill range; all have a 50° roll back bucket and a pry-out force of 7,400 lb.

The general purpose model RD2 is illustrated. The FD2 has front wheel drive and is useful for down hill loading and for working in loose materials: the FD4 has four wheel drive with the ability to disconnect the back wheel drive if desired.

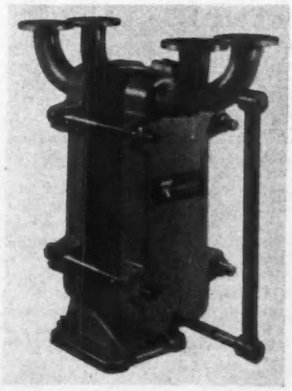
All three machines are driven by a Fordson Major engine developing 56 h.p. at 1,800 r.p.m. Transmission is through a Borg and Beck 13 in clutch and a constant mesh gearbox providing six forward speeds and line reverse.

Double acting rams operate the tip and bucket and the clear height under the tip is 11 ft. Maximum outreach is 5 ft 10½ in for the RD2 and 5 ft 5½ in for the FD2 and FD4 models.

The turning circle of the RD2 is 30 ft and excellent visibility is one of the main claims. The cab is totally enclosed and is fitted with a bucket seat. A full range of general and special purpose buckets is available ranging from ¾ to 2 cu. yards. Extras include power assisted steering and hydraulic transmission with torque convertor and epicyclic gearbox. *E. Boydell and Company Limited, Old Trafford, Manchester 17.*

HEAT EXCHANGER

Pressures Up To 210 lb per sq. in



NOW available in this country is the Rosenblad series of heat exchangers of plate design.

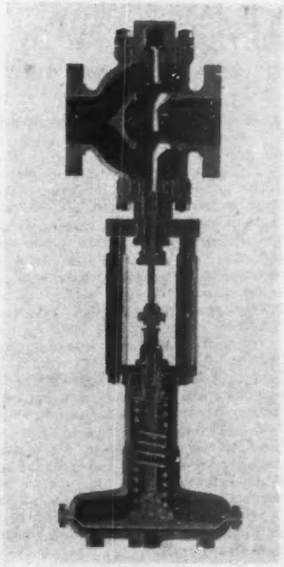
Particular advantages claimed are that the standard unit will withstand a pressure of 210 lb per sq in and that the heat transfer coefficient is very high. The frames are made in various sizes and contain the plates which have herringbone corrugations in the transfer area. Adjacent plates are arranged so that a very large number of these corrugations cross at uniformly distributed points. Large flow ports are included at each corner of the plates. Manufacture is by pressing and there are no welds.

Moulded gaskets of composition rubber are used between the plates and cemented in position to prevent damage during assembly or dismantling. The plates are suspended from an upper aligning bar and clamped in place by the end frames. The standard gaskets give a seal up to pressures of 360 lb per sq. in. A light duty version is also made for lower operating pressures.

The capacity of the unit depends on the number of plates incorporated and thus sizes can be built up to suit most requirements. The pressure drop across the exchangers is low due to the large flow ports. *British Boiler Accessories Limited, 62-63 Fenchurch Street London, EC3.*

DOUBLE BEAT VALVE

Full Flow Characteristics



NOW being made in this country is the DB/15 double beat valve illustrated, which has full flow characteristics.

The valves are made from 1½ in to 4 in diameter and of various materials. Standard ones include cast steel and 0·5 per cent molybdenum cast steel. Alternative body materials can be supplied. Stainless steel is used for the plugs which are available in parabolic and equal percentage designs. Guides and seat faces are Stellited in some models. All valves in the group are fitted with En 38E stainless steel spindles to give durability and resistance to electrolytic action.

To prevent seat rings and guide bushes working loose these items are screwed and welded. All spindle guide bushes are of nitrided steel. The stuffing box is packed with graphite impregnated asbestos. The valves are of the deep packing type having a ratio of depth to width of 6 : 1. Steam sealing to gland can be provided if required. Flanges are made in standard ranges. *British Arca Regulators Limited, Sisson Road, Gloucester.*

German Industries Fair Hanover 1960

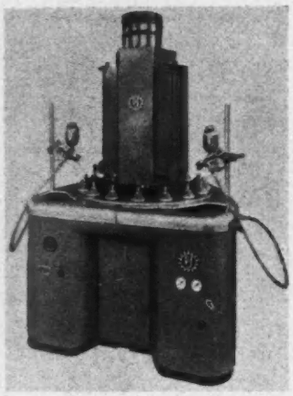
SINCE its beginning in 1947, the Trade Fair at Hanover, held each year at the end of April, has become one of the great fairs of Europe. There were over 4,750 exhibitors this year and many unsuccessful applicants for space. The site occupies about 12 acres of which two-thirds are covered.

More than 800 exhibitors came from elsewhere than Germany and, in all, 25 countries were represented. Products ranged from glass and ceramics through plastics and building materials to electrical consumer products, capital goods, internal-combustion engines, refrigerating machinery, optical instruments and woodworking machinery. Machine tools were not included in this fair owing to their having one of their own later in the year. On this occasion, electric lamps and lighting equipment had a five-storey building all to themselves.

British exhibitors were well scattered through the 18 halls with a strong representation in the internal-combustion engine section and an impressive group stand in the electronics division. Apart from the main exhibition there was also an aviation display at the Langenhagen airport where Britain was also well represented. Attendances look like being considerably higher than last year, as over 150,000 visitors came the first day.

LACQUER SPRAY

Automatic Operation



INNER and outer surfaces can be spray lacquered or painted on an automatic machine fitted with a central fume extraction unit.

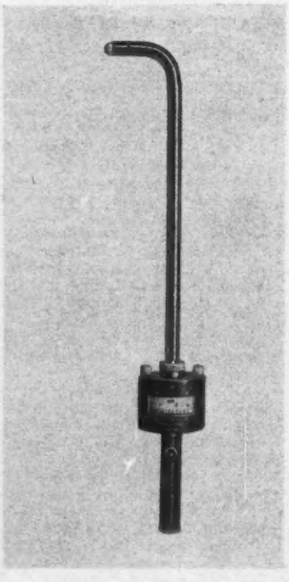
Lacquering is performed on a round able basis with work carrying spindles that rotate in both directions. The pneumatic controlled spray units are vertically adjustable with a travel of 19⅝ in so that loss of paint can be kept to a minimum. Unskilled labour can be used.

Five models are made with 8, 16 or 32 working spindles and either one or two spray positions. Output depends on the size of the work piece and this may be up to 11⅛ in diameter with 8 spindles; 5¼ in with 16 spindles; and 1¼ in with the 32 spindle arrangement. The height of the work piece can be up to 19¾ in. The number of strokes made by the guns over each piece can be from 8 to 30 per minute, which is equivalent to an output of from 480 to 1,800 pieces per hour for a single gun machine.

The central filter portion of the extraction equipment is supplied as standard. The individual filters can be removed for cleaning. With this arrangement it is not necessary to wear a mask while spraying. A built-in centralised lubrication system feeds all points. *Peter Ilmberger, Wittelsbacherhöhe 50-52, Straubing/Donau, Germany.*

PORTABLE FLOW METER

For Gases



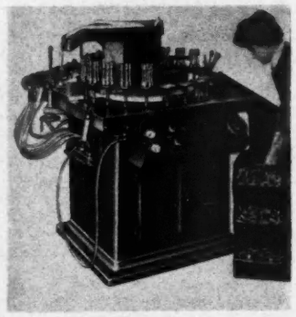
A PORTABLE flow meter can be used to measure the rate of flow of air or gas within a range of speeds up to 50 m per sec (approximately 160 ft per sec).

The instrument uses the principle of blade deflection and therefore the calibrations depend on the density of the gas concerned. Correction tables are included. In operation the head is inserted into the gas stream and gas enters passing through a dust screen before reaching into the measuring chamber.

The hooked tube can be turned through 360° so that the scale can always be read easily. There are four ranges for the full speed coverage, changing both nozzle and scale by milled screws in the body. Illumination for the scale is provided by a battery in the handle. Accuracy is within 2 per cent of full scale deflection and the meter will operate over temperatures from −20 to +120° C. Tubes can be 16 in, 27 in. or 39 in long. *Wilh. Lambrecht, Göttingen, West Germany.*

BRAZING MACHINE

Automatic Cycle



THE Elga-Record brazing machine is designed for continuous work with high production capacity.

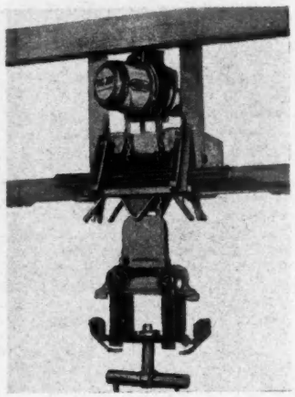
There are 20 revolving plates on the main turntable each 100 mm diameter (3·9 in approx.) and resting on a ball bearing. Working level is 95 mm above the frame. The table is rotated by a 0·35 h.p. motor at speeds between 0·4 and 2 r.p.m. as desired. Mounting fixtures can be fitted to the plates.

In the standard machine there are 12 separate blow pipes for main heating and three for preheating. Each is individually adjustable for position and flame size so that the flame will give the best results. The whole assembly is controlled by a central shut off valve. The blow pipes can be chosen for propane, acetylene, hydrogen, or town's gas.

The work is rotated as it passes the flame and subsequently is cooled by an air blast from a shaped nozzle. Immediately after the air blast an arm operated by compressed air pushes the work off the plates, normally directly into a quench bath. On the control panel at the front are the two main valves for gas and oxygen with their corresponding pressure gauges. Controls for the cooling air and the drive motor are in the centre and at the left is the wheel for speed regulation. A pilot light is provided for lighting the main heaters and has a separate control valve, also on the main panel. *Elektro-und Gasapparatebau GmbH, Johannisstrasse 14, Saarbrucken, Germany.*

TRANSPORTER

Power Work Lift



CLAIMS for a new transporter system are that it can operate with any number of work stations and is independant of a rigid time cycle.

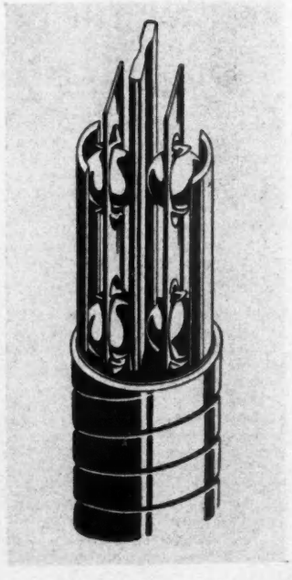
The workpieces are suspended from trolleys consisting of a loading hook carried on two pairs of wheels. These run on the flanges of an overhead beam, propulsion being by hand. Above each work station is a hoist, usually electrically driven and controlled from a pendant panel or from the work bench, the chain being passed round a sheave held in brackets fixed to a short length of track. Thus workpiece, trolley and the short track section are lowered as one unit, the trolley being held by a gravity clip.

At each side of the fixed track is hung a guard beam that swings down as the unit is lowered and stops the approach of another trolley from either direction. As the unit is raised back into place again it raises with it these beams so that the trolleys can pass.

The trolleys are capable of carrying workpieces weighing up to 6 cwt, and hooks can be designed to suit all shapes. Points can be inserted in the trackway to divert trolleys to different lines or to by-pass some particular work-station. Lowering can be controlled very accurately to position the part on the machine. *R. Stahl Maschinenfabrik, Ulmer Strasse 231-239, Stuttgart, Germany.*

REMOTE CONTROL

97 per cent Efficient



A MECHANICAL remote control system for push and pull operation has a working efficiency of 97 per cent with almost no backlash.

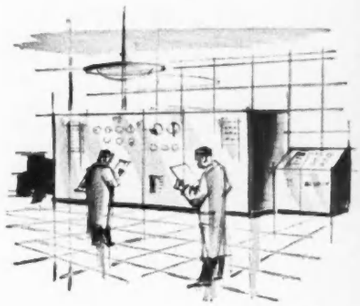
The system, known as Flexball in Germany and Bowdenflex in this country where it is made by Bowden (Engineers) Limited, has an outer armoured tube and a power member consisting of one or two flexible strips. On each side of the power member are rows of ball bearings in cages which act as running guides between the power strip and outer "races" running the length of the tube.

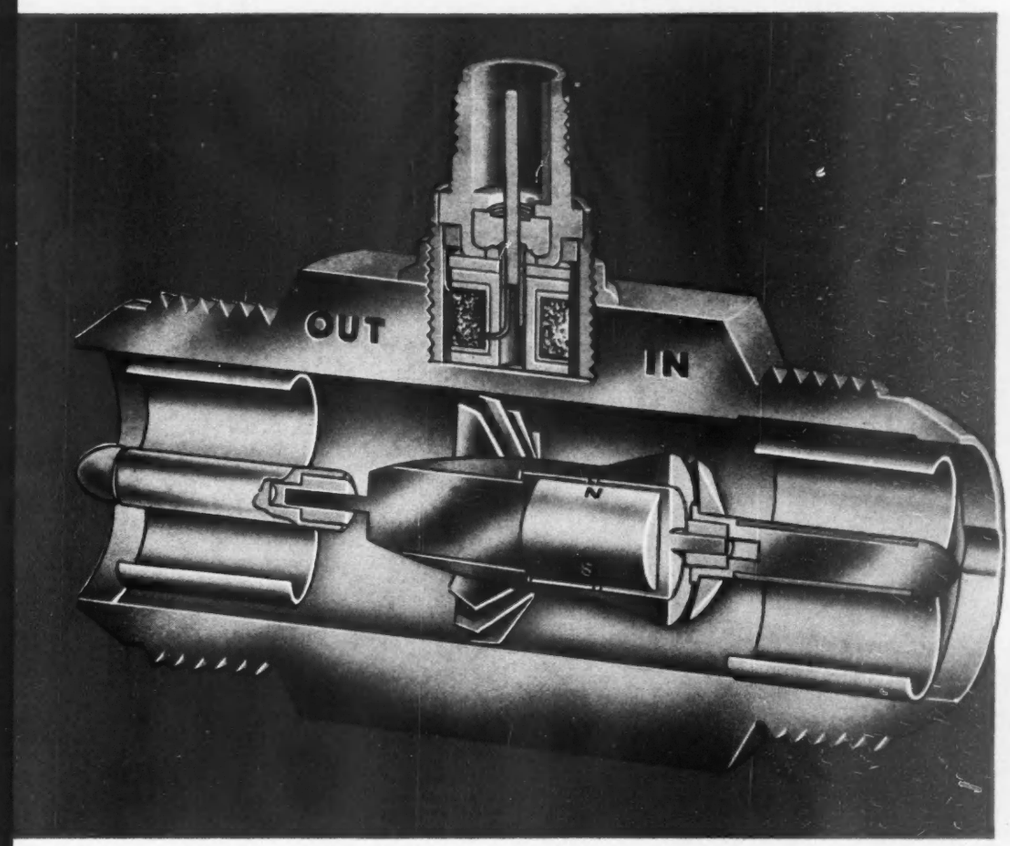
Six sizes are made with diameters from 9 to 16·8 mm (0·35 to 0·63 in approx.); corresponding minimum radii are 80 and 150 mm. Load capacity of the largest is 1,000 kg (2,200 lb) in tension falling to 500 kg for a push action with a stroke of 100 mm. The action is unaffected by temperature changes and lengths of 200 ft have been made. *Vofa-Werk, Loricker Strasse 106, Düsseldorf-Oberkassel, Germany.*

Wherever information on fluid flow is required,

the de Havilland POTTERMETER

sets new standards of accuracy and reliability





This new turbine-type flowmeter enables major advances to be made in the techniques of flow measurement and control. The de Havilland Pottermeter is the only flowmeter which offers all these features:

- **Accuracy to ±0·1% or better on repetition work, ±0·5% or better over a 20·1 range. Calibration remains constant for a variety of liquids over wide flow ranges.**
- Contains only one moving part—no thrust bearings—operates with a minimum of maintenance at high temperatures and pressures.
- No larger than the pipeline in which it is installed—may be mounted in any attitude.
- Can be supplied with indicating, recording and process control equipment—gives digital presentation of results.
- Can measure volumetric or mass flows.
- Models available to measure flows from 0·1 to 40,000 Imperial gallons per minute, at a wide range of operating pressures. Larger and smaller sizes made to order.
- Can measure flow of any liquid or gas, irrespective of its lubricating or non-lubricating properties, at temperatures ranging from -455°F to 1500°F.
- Manufactured as standard in stainless steel—can be made in any non-magnetic material.
- Rapid response rate permits transient flow studies.

The de Havilland Pottermeter will be demonstrated on
STAND Q.730
at the
I.E.A. EXHIBITION
Olympia
May 23 to 28

Write now for further details to:

DE HAVILLAND PROPELLERS LIMITED

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Rolled and forged steel rings . . .

Forged rings up to
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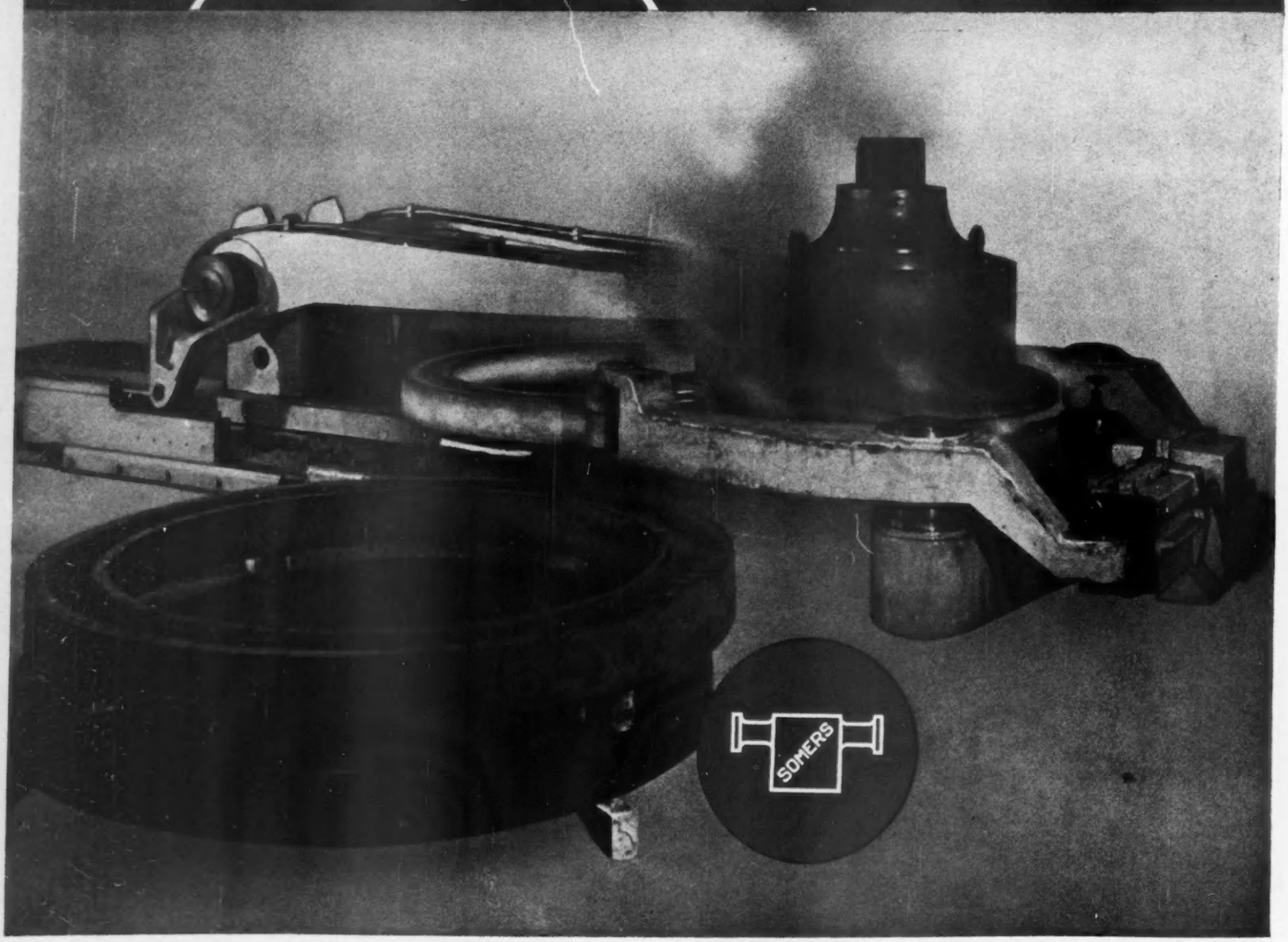
Upset punched rings
down to 6in. O.D.



Walter Somers Ltd.

Hales Owen · Near Birmingham

Human Element

Executive Appointments Falling Off?

THE number of managerial and technical jobs with salaries of £1,000 a year or more advertised in six representative newspapers in the first quarter of the year fell 14 per cent below the number in 1959's last quarter.

The result is a fall in the Management Selection Index from 117 to 101 (100 = average for all 1959).

Management Selection Limited, the consultants who devised and produced the Index, have added a miscellany of economic snippets from "the note of caution" in the Budget to increased bank advances and the fall in the number of unemployed. By way of a background to management employment policy this all appears to about cancel out.

The same quarter last year produced a fall of only three points where the first quarter is this year down by 16. It may perhaps appear when the Index has been running for a rather longer period that there are seasonal factors affecting the first three months of the year.

Comparing the two quarters, the smallest drop, 10 per cent, was in the advertisements for accountants. The largest was in those for production men, 16 per cent, although sales and those lumped together as "others," which includes purchasing and personnel management, were close behind at 15 per cent.

In the much smaller group titled general management, there was an opposite trend: 36 per cent more advertisements.

After the Street Walker The Road Offender

A population armed to the teeth with motor vehicles, pedestrians running for their lives at the approach of a car, the motor as the H-bomb of town planning; these were a few of the remarks heard at last week's Planning for Road Safety Conference in London.

The Pedestrians' Association organised the meeting and some of the most startling moments came from its president, Dr. A. L. Goodhart.

The streets had been cleared of street walkers by the introduction of realistic fines and penalties and the prospect that they would be enforced. Until this was done moral persuasion and police guidance got nowhere.

Dr. Goodhart pointed out that it was still cheaper to run a car in a dangerous condition of neglect than it was to have it repaired. The average fine for speeding was still the same as it had been —pre-Wolfenden—for soliciting. Dr. Goodhart described it as a cheap licence for the man who wanted to break the law.

If the motoring laws were properly enforced, and Dr. Goodhart could have added—if they were revised as in the Street Offences Bill, the young driver, especially the motor cyclist, would be protected against himself. The young reckless driver was as great a menace to himself and others as the young street-walker.

Mr. C. D. Buchanan, who wrote *Mixed Blessing—The Motor in Britain*, said that one of the most serious manifestations of the motor age was the pedestrian-vehicle conflict. This showed itself in direct collisions, the assailing of the nerves, battering of the senses by noise and pollution of the atmosphere. It was wrong that pedestrians should take it for granted that at the approach of a motor-car they had to run for their lives.

Mr. Buchanan came near the heart of the matter when he said that the motor had made out of date much of the traditional shape of towns. Some spectacular engineering would be needed, he thought, to distribute major traffic flows.

The chief information officer of the Royal Institute of British Architects, Mr. Malcolm MacEwen, was even more direct. The car was being used wastefully, selfishly and stupidly and causing casualties on the military scale.

We had not yet experienced anything like the full impact of the motor vehicle and nothing was being done to cope with the crisis which the extra flood of vehicles would cause in the next five or ten years.

Mr. MacEwen asked when was money on the scale of missile research going to be spent on research into the planning engineering and architectural problems of city reconstruction. If we failed over that the car could prove to be the H-bomb of city planning—the most expensive misdirected missile of all.

TUC May Find ETU Nettle More than Prickly

Plainly the TUC is determined to have it out with the Electrical Trades Union. Before last week's meeting of the Finance and General Purposes committee it was not hard to find those who were saying that a determined effort would be made to persuade the TUC to take no further action by some of its own members.

Apparently the excuse to be advanced was that the ETU in pointing out that one of the rebels was taking legal action to get his due rights had made out its claim for no further action being possible. Since the individual in question had in fact taken no legal steps, and had promised not to if a judicial inquiry were accepted, such a result would have been received with derision.

In the end the TUC has gone as far at this stage as the sternest could require. The ETU, its leaders have been told, will be suspended from affiliation unless they choose, by 18 May, between suing those who have alleged improper practices or submitting to a judicial inquiry.

If the outcome is suspension of the 250,000 member-union the question will be debated at the September annual congress and on a majority decision the union may be disaffiliated with immediate effect.

What may secretly worry some of the leaders of the mass membership unions is that disaffiliation would leave the road open to a recruiting campaign throughout industry, both to and from the ETU.

With a reputation for "getting results." With the practice of calling locally started strikes official unless there is special cause, the reverse of most other unions' methods. And not least from the spectacular position of fighting for greater rewards, against "the capitalist Press" and against the right-wing TUC, there can be no certainty that the disaffiliation would not go on for years and the members come rolling in.

Special Methods and Problems of Older Workers

That special training methods for older workers can produce results better even than with school leavers is brought out clearly by an example related in a new Department of Scientific and Industrial Research pamphlet.

The case told in some detail is of training in wool textile mills. Demonstration and description had failed. There is indeed evidence that memorising of verbal descriptions and testing by the amount of recollection in words penalises the older trainee.

The experimental method introduced into the mill problem taught the older workers the detailed patterns of the weaves by using cloth specially woven with much larger threads than usual. They then copied the weaves on to small frames using thick elastic instead of thread.

Having mastered the weaves they were able to transfer them to normal cloth. Constructing the weaves themselves freed the older trainees from verbal descriptions and word memorising.

The practical effect was that the trainees in the age group 30 to 50 learnt much faster than school leavers.

The pamphlet which relates this significant tale is *The Older Worker and His Job*, by Hilary M. Clay, published for the DSIR by the Stationery Office, price 1*s* 3*d*.

Since half of all the men at work are over 40, which has been drawn as the booklet's arbitrary line, accurate knowledge of the subject must be valuable.

When the older worker says he is moving to lighter work he often in fact goes to physically heavier work. A more accurate phrase would be moving to slower work, or work that he can do in his own time.

The speed factor in semi-skilled operations seems to push men out, or cause them to leave of their own accord, once out of the thirties. There are cases where teams, whose piece-work earnings depend upon the rate they can keep up, request that they shall not be held back by reliable but slower men of greater years. This sort of thing is why there are more older men in unskilled and manual work where the pace is not so hot.

On one car assembly line it was found that older men complained of being "kept on the go all the time" and asked for transfer to the rectification benches at the side of the line, where they could do similar work at their own pace.

Laboratory observation has demonstrated that slowing down is not so much due to loss of speed in muscular movement but slowness of making decisions and relating what is seen to what is done. This plainly suggests that much could be achieved by so arranging the job that decisions to be taken and signals coming from the work were spaced out and clear.

Some interesting facts have been verified about forgetfulness. While well established memories seem to remain clear, retention of what has just been observed declines with age. This seems to begin in a subtle way much earlier than had been thought.

The practical difficulty for older people seems to be that of remembering something while doing something else. The best example is the man who looks up a telephone number and then forgets it while he is finding the letter he wants to use during the telephone call.

The *Older Worker and His Job* draws largely on *Ageing and Human Skill*, by A. T. Welford, Oxford University Press for the Nuffield Foundation, and also on other research studies.

Right Turn at Your Own Risk

Valuable suggestions for small road alterations that would reduce the heavy toll of road casualties at rural road junctions are made in a road research technical paper (No. 47) by members of the Department of Scientific and Industrial Research's Road Research Laboratory.

It is unfortunate that the figures used had to be those of the year 1953, the last for which complete information was available. The 11,871 personal injury accidents at junctions in non-built-up areas were 27 per cent of all personal injury accidents in the rural districts. Over 4 per cent were fatal accidents and almost 40 per cent involved fatal or serious injuries. The percentages are about twice those for accidents in built-up areas.

A table of the 11,871 accidents at rural junctions showed that 5,053 involved two vehicles at T or Y intersections and 2,661 concerned two vehicles at crossroads. The only other entry on the table to reach four figures were the 2,021 accidents involving one vehicle at T or Y junctions.

When 523 manoeuvre accidents were analysed it was found that 62 per cent involved right-turners. 25 per cent of the accidents were collisions between cars turning right from the major road and another travelling in the same direction.

Turning to what the road engineer can do about it, paper No. 47 gives a significant table of the results obtained in altering the angle of entry of minor roads into the major road.

Change	*Decrease in personal injury accidents not involving pedestrians*
Squaring left-hand splays	20 per cent
Squaring right-hand splays	90 per cent
Sharpening turning movements at square junctions	20 per cent

Earlier research workers have shown the advantages of staggering crossroads instead of allowing one road simply to plunge across another, with serious effects on the accident rate.

A reduction of about 60 per cent in injury accidents and possibly more in more serious accidents is now believed to be achieved by converting straight-over crossroads into left and right staggers.

The Road Research Laboratory paper goes on to give details of the gap, of sometimes only six or seven seconds, between cars in the major road stream which other drivers will take to enter from the minor road. From these it makes important calculations on the visibility that should be allowed if motorists approaching from side roads are to be aided and not allowed to run blindly into accident provoking situations.

It is one more of the publications from the laboratory whose application could not fail to give a measure of greater safety to those on the roads.

Engineering Growth in the Midlands

High industrial concentration and high labour costs characterise the Midlands, with the motor car and its components setting the pace. Survival in such a climate means more machines per man.

By H. J. Novy

Halting in the Midlands for the sixth article in his series, Mr. Novy considers Britain's most productive area. Continuing next week, he stops in South Wales before proceeding finally to London.

THE industrial prominence of the Midlands was explained to me in several ways. Birmingham had been a refuge of dissenters fleeing from religious persecution in corporate towns, taking their skills with them. It also occupied a good strategic position, at the point where the roads from Halesowen, Dudley and Wednesbury, all ironstone districts, crossed the river Lea. Certainly the presence of ironstone deposits in the Black Country had a profound influence on the birth of engineering trades.

The very early granting of a market charter (in 1166), of the right to hold fairs (in the 13th century), and the consequent growth of the town as a central market for a vast agricultural area. Textile and leather cottage industries prospered from its very early years, and encouraged craftsmen to settle there. The "gild" system did not apply in Birmingham, allowing unusual freedom for private enterprise. This tradition of freedom has persisted almost complete until the days of industrial development certificates and compulsory purchase orders.

But there are many other factors to explain the tremendous growth rate of the region's industry. In the 16th century it became an important stage on the road from London to Chester and therefore within easy reach of the great importing centre of Merseyside. The civil war led to a considerable expansion of the cutlery trade, with the manufacture of swords for the occupying Parliamentarians. From this beginning developed the country's largest armament and munitions industry and its unequalled brass trades.

The history of the Kynoch works of ICI, which moved to Witton in 1862 from Birmingham—already becoming crowded with industry—manufactured percussion caps and then cartridges. In the 1880's they found that supplies of brass strip could not be obtained in the consistent quality required and so started to do their own rolling. Kynoch works employs 10,000 of the 14,000 labour force of ICI Metals Division, now one of the largest non-ferrous metals manufacturers in the Commonwealth. About 500 people are engaged in engineering and research, of whom nearly one-quarter are graduates.

Another considerable influence on the development of Birmingham and Midland industry was the infectious enterprise of some of its pioneers. Among these Matthew Boulton is outstanding. The works he built in Soho, known as the Manufactory (now The Mint, Birmingham Limited), employed 1,000 workpeople by 1774 on the manufacture of silver plate, buckles, buttons, watch-chains and many other small metal wares. It was Boulton who anticipated the factory system and, by his support of James Watt, made the system workable through the development of the steam engine. It was in Birmingham that the first commercial steam engines were made.

CRAFTSMEN

The part of the craftsman should not be underrated. Even before the industrial revolution thousands of smiths were working metal in their homes, making ornaments and, later, components for machines. The confidence that almost anything in metal could be made cheaply "round the back" encouraged industrialists to establish vast assembly trades based on small bought-out components made to close tolerances.

Midland industry is varied and versatile—it has shown an outstanding propensity for adapting itself to changes in demand. There has been a considerable growth in the population of the region as a whole, by some 14 per cent since 1939, largely through immigration from the country's depressed areas, such as Merseyside, Ireland and Scotland and also from overseas, particularly the West Indies. In surveying the pattern of industry, East and West are considered separately, partly because they exhibit different characteristics, partly because statistical information is not provided for the region as a whole.

In the West, the official "Midland Region" which includes Herefordshire and Shropshire as well as Staffordshire, Warwickshire and Worcestershire, there is a working population of 2·14 million which is 8·7 per cent of that in the United Kingdom as a whole. Nearly 56 per cent of the working population is employed in manufacturing industry, in which metal manufacture and metal-using industries predominate. The numbers employed in the manufacture of engineering products and electrical goods accounts for nearly 12 per cent of the country's employment in these industries and for approximately the same proportion of the region's labour force. Employment in the manufacture of vehicles accounts for about one-fifth of the UK total and for less than 12 per cent of the region's labour force, but this figure relates to direct employment only and it is estimated that at least one-fifth of Birmingham's workers and a quarter of Coventry's, work in the production of road vehicles.

The net output and employment of metal and metal-using industries in the West Midlands is shown in the table. Although the figures are for 1954 the general picture has not changed radically since then. In fact the region's labour resources coupled with the stiffening attitude of the Government on the granting of industrial development certificates has tended to "freeze" the industrial pattern, and to force expansion into other areas. The motor industry's overspill into Merseyside and Scotland is evidence of this, as was the earlier tendency of the non-ferrous metal industry to find a new home in South Wales.

CONCENTRATION

An important factor which must affect any further substantial growth of metal-using industries in the West Midlands is the tendency of all industry to be clustered in the Birmingham-Coventry area. It is estimated that nearly two thirds of all manufacturing industry is concentrated in the "West Midland Conurbation," only slightly less of the engineering industries and nearly 70 per cent of vehicle manufacturing.

The pattern of employment and industry in the East Midlands is also given in the table. In this region there is of course a much greater concentration of coal mining and steel making, and industrial development has been considerably affected by the coalfields of Nottinghamshire, which are still developing, and the ironstone mines of Northamptonshire. Productivity in the coal mines is almost twice the national average, and output is expected to rise from 45½ million tons in 1958 to 49 million tons in 1965. Together the East and West Midland coalfields, which are well placed for inland and export markets, account for nearly 30 per cent of the country's coal production.

Industrial expansion since the war has been limited both by lack of space and by shortage of labour but it has nonetheless been substantial. Industrial building during the 14 years 1945-58 has added 55·2 million sq. ft to the region's factory capacity, more than to that of any other region, including London and the South East. Leaders in this expansion were motor vehicles (12·0 million sq. ft), followed by engineering and electrical goods (10·2 million sq. ft), metal manufacture (8·4 million) and metal goods (7·0 million). The only other industry to expand significantly was coal mining.

Textiles which are a major activity of the Leicester-Nottingham area expanded by only 2½ million sq. ft despite the remarkable growth in demand of knitted apparel and the rapid development of some of the larger units in the area, such as N. Corah and Sons, William Hollins, and others. Over 60 per cent of the country's hosiery and knitwear capacity is concentrated in the East Midlands.

NON-FERROUS METAL

The Kynoch Works of ICI Metals Division is built on a 250 acre site at Witton and is the country's major copper and brass strip, sheet and rod works. It has also become a leading centre for the manufacture of titanium, zirconium and berylium. Other ICI factories in the area are Amal Limited at Witton and Marston Excelsior Limited at Wolverhampton.

Three other major companies in the non-ferrous metal field are Delta-Booth, who specialise in aluminium rolled products, High Duty Alloys, whose Redditch works enjoy a world reputation as makers of precision forgings in aluminium and steel, and McKechnie Brothers in Walsall, who have made considerable headway in the production of special non-ferrous alloys. The fact that the Institute of Metals and the British Non-Ferrous Metals Association were both founded in Birmingham (in 1908 and 1920 respectively) is evidence of the region's great importance in this field.

Probably the largest of all the Midland manufacturers of metal products is Tube Investments Limited, one of the major world producers of steel tubes, who, in recent years, have become the largest makers of bicycles and, in association with Reynolds Metals Company of Richmond, Va., USA, the country's leading manufacturers of aluminium products. The production of steel tubes began in Birmingham, yet another industry to have its roots in the early development of firearms. Tube Investments, formed in 1919, rapidly rationalised the tube making industry and developed a wide range of precision and specialised tubes—from capillary size to 39 in diameter—in all kinds of alloy steels, aluminium, titanium, plastics and combination materials. The acquisition of interests in the cycle industry, culminating in the recent offer for Raleigh Industries, is a natural extension into one of the major tube-using industries.

Guest Keen and Nettlefold is another very large company with its roots in the Midlands. The group comprises 84 companies, including 26 overseas, and employs over 72,000 people. Their major steel making subsidiaries are John Lysaght's works at Scunthorpe and Guest Keen Iron and Steel Company in Cardiff, and they own the largest forge in the country, Garringtons,

and leading steel fabricator, Joseph Sankey and Sons, who also make special-steel sheets.

Another major group in the region which is mainly concerned with the manufacture of steel products is the Owen Organisation, whose parent company is Rubery, Owen and Company in Darlaston. The group employ some 14,000 people, about half of them on the 75 acre Darlaston site. This is one of the largest private companies in Britain, and the range of activities now includes agricultural machinery, mechanical handling plant, compressors, machine tools and engineers' tools. But the main business is in steel fabrication and the manufacture of components for the motor and aircraft industries.

The iron industry of the North Midlands, together with coal, still forms the basic industrial activity of the Derby-Chesterfield area. Stanton Ironworks, Staveley Coal and Iron and Sheepbridge are the largest units in an industry which employs nearly 60,000 people.

One thing is clear—short of a miracle change either in the policy of our Government on industrial location or in car design—vehicle production in the Midlands will not increase greatly over the next decade. Four years ago, when vehicle production in Britan was nearing its post-war peak, the net output of firms classified as manufacturers of cars, lorries, aircraft, cycles, motor cycles and rolling stock totalled £228 million, nearly one-third of these industries' net output in the UK. This was concentrated in relatively few hands: the British Motor Corporation, whose main works are Austin's factory at Longbridge, where over 20,000 are employed, Rootes, Standard-International, Jaguar Cars, Rover and Rolls-Royce. Ninety per cent of Britain's cycles and 75 per cent of motor cycles are made there, mainly by four firms: BSA, Associated Motor Cycle, Tube Investments and Raleigh Industries. A very large proportion indeed of electrical accessories for the vehicle and aircraft industries are made in the region by Joseph Lucas and Company; of bumpers, window regulators, door handles and other body accessories by Wilmot Breeden; car bodies by Pressed Steel and Fisher and Ludlow (now a BMC company), glass by Triplex, iron castings by Qualcast and many other large firms. Employment in vehicle manufacture in the region probably exceeds 250,000 in the West and 90,000 in the North-East.

Such heavy concentration in one industry was explained by Wilmot Breeden: "The function of a motor car manufacturer is primarily to assemble bought-out components. Because of the bulk of material used, the manufacturers hold very small stocks—generally not exceeding a few hours' usage. We may, therefore, be regarded as part of the manufacturers' assembly lines and it is important that we are located either close to the manufacturers or are served by excellent communications with them. Birmingham satisfied both these requirements."

There is little or no prospect of securing industrial development certificates which would allow the industry to continue the expansion of its factory space at the rate of 860,000 sq. ft per annum as it has done since 1945. The housing and other problems are considered too great. Nor is it likely that the trend in productivity will be maintained: the value of sales at Austin's Longbridge factory rose from 5*s* 0½*d* per sq. ft in 1952 to 11*s* 2½*s* in 1959, but the company's labour costs represent only 8 or 9 per cent of such a figure and it is doubtful whether further large investment in plant and automatic techniques would be economic in view of the very small potential saving in labour costs. Nevertheless, labour "tightness" has led the industry look for the highest possible productivity.

The rapid growth of these industries in the Midlands was strongly influenced by the development of the motor industry in the region. The Dunlop Rubber Company employ over 9,000 people at Fort Dunlop, which may be regarded as the technical and production centre of a group employing nearly 100,000 people in Britain and overseas.

EXPORT OF PRODUCTION KNOW-HOW

Plastic manufacture began in Birmingham at the beginning of the century when Sir James Swinburne discovered a method of producing phenolic resins. The company he founded was a forerunner of Bakelite Limited. Laminated plastics were also "fathered" in the region, where George Ellison Limited, and Tufnol Limited helped to pioneer their development.

The region is also a centre of manufacturing know-how, and the BMC engineering department at Longbridge "export" production techniques to other factories in the group. Courtaulds have designed complete rayon factories for Russia, and Dunlop have likewise undertaken comprehensive engineering work for the largest tyre factory ever to be built in the Soviet Union.

The General Electric Company's factory at Witton is the largest of several they have in Birmingham. Birlec Limited are said to be the largest makers of electric furnaces in the country. In Coventry Alfred Herbert are the largest unit in a lively centre of machine-tool manufacture, which employs rather more than 30,000 people in the main Birmingham-Coventry area alone.

Among the leading engineering firms in the electrical engineering industry are Associated Electrical Industries (Rugby) Limited (embracing what was formerly British Thomson-Houston), Brush at Loughborough, and Ericsson's Telephones at Beeston. Rolls-Royce are at Derby, where there is also a major British Railways locomotive and wagon works. Imperial Typewriters are at Leicester, Raleigh at Nottingham, Aveling Barford at Grantham, John Thompson, who are leading makers of boiler plant and a wide range of engineering products, at Bilston, Metropolitan-Cammell Carriage and Wagon Company at Birmingham, Massey-Ferguson at Coventry, and so on.

I find it difficult to visualise the Midlands of 1970. It is an area of great prosperity with major problems of shortages, of space into which to grow, and of labour. The main hope of industrial growth lies in greater productivity.

The major cities of the Midlands continue to grow, and in Birmingham great changes are taking place in housing and road building. The new inner ring road, said to cost as much for its three miles or so as the 63 miles of M1, is changing the whole city. Upward growth is already taking place and must go on at an accelerated pace. I returned from my trip with the feeling that too little had been done to make possible the further industrialisation of the Midlands and the conclusion too easily reached that it could not be done.

Considering the very large number of small firms in the region, many of whom are of the "back street" type I wondered whether the process of amalgamation and take-overs already begun could not improve matters and release both space and labour. Boom conditions unfortunately favour the existence of the inefficient and hamper the growth of the efficient. Yet the comment of Mr. John Brockhouse, chairman of J. Brockhouse and Company, was explicitly in favour of the mixture, small and great: "Diversification of its industries has meant that it has never known times of serious depression, and further, has developed a large nucleus of skilled men in many trades which has made further developments possible. It still contains a large number of small businesses and from this generates a diversity of crafts and a vitality and independence which are of great value." But, he added, "with regard to the future and its problems, I must say I view with some alarm the Government restrictions on development in this area, which are tantamount to a stand-still order. Industry must grow if it is to be healthy and if this restriction is applied strictly, in ten to fifteen years time the Midlands may well be suffering the consequences." I share this view.

The managing director of Brush was inclined to accept the situation and find solutions elsewhere, foreseeing that more of the company's products would be hired-off to other sites. He complained that, although labour is experienced, it is also steeped in tradition and that "custom and practice loom large."

What may well happen in the long run, is that mechanical and electrical engineering firms will look to other locations for expansion and may even transfer existing works. This point was made by Aveling Barford, who suffer from a shortage of skilled labour although they are one of the largest producers of agricultural machinery and mobile contractors' plant in the country: "the motor car industry being the biggest and the simplest, and paying high wages for even the lesser skills, draws off the cream." That is the main argument of course for the concentration of capital-intensive manufacturing in one location, for labour-intensive processes cannot pay competitive wages.

Returning on a similar task to Birmingham, Coventry, Leicester, Derby and other towns in the region in ten year's time I would expect to find a substantially increased population housed in tall blocks of flats, working mainly in light to medium engineering, and using a preponderance of transfer and other labour-saving machinery. Small-scale industry's survival may well depend upon its ability to make use of the new control techniques which are beginning to gain acceptance for the production of complex items in areas of high labour cost.

Employment and Output of Engineering Industries in 1964: West and East Midlands

Industry	West Midlands Net output, £1,000	West Midlands Total employment	East Midlands Net output, £1,000	East Midlands Total employment
Iron and steel (melting and rolling)	22,021	20,709	24,860	17,269
Iron foundries	22,977	30,024	15,914	18,632
Steel sheets	1,098	2,048		
Wrought iron and steel tubes	17,393	20,790	5,102	5,852
Non-ferrous metals (smelting, rolling, etc.)	43,050	46,013	751	796
Blast furnaces			14,208	11,085
Blast furnaces and tinplate	1,533	2,131		
Machine tools	26,872	26,995	4,709	4,838
Textile machinery and accessories			6,762	8,120
Constructional engineering	9,049	9,649		
Mechanical handling equipment	2,465	2,754	3,559	3,635
Printing and bookbinding machinery			358	414
Mechanical engineering (general)	52,976	61,875	52,580	60,022
Mechanical engineering (repairing)	2,717	3,541	2,216	3,010
Electric wires and cables			1,021	1,140
Electrical engineering (general)	57,605	74,396		
Radio and telecommunications	9,047	14,600		
Marine engineering; small arms; construction; electrical			23,501	29,425
Marine engineering; textile machinery small arms; electrical	9,009	12,119		
Motor vehicles and cycles (manufacturing)	143,129	163,532	19,167	19,028
Motor vehicles and cycles (repairing)	3,065	4,915	2,499	3,888
Aircraft manufacture and repair	23,344	27,187		
Aircraft manufacture and repair; railway locomotive shops and locomotive manufacturing; and carts, perambulators, etc.			22,909	26,498
Railway carriages and wagons and trams	7,735	10,729	5,641	9,834
Tool and implement			471	671
Chain, nail, screw and miscellaneous forgings	36,527	47,770	2,506	3,474
Wire and wire manufactures	5,356	4,935	1,346	1,444
Hardware, hollow-ware, metal furniture and sheet metal	48,794	68,031	4,826	6,069
Cutlery			270	432
Brass manufactures	16,169	24,287	161	228
Needles, pins, fish hooks and metal smallwares	7,963	12,595	1,040	1,584
Scientific, surgical and photographic instruments, etc.	2,221	3,324	1,156	1,577
Jewellery and plate	5,468	8,102		

Structural Efficiency of Pratt Trusses

Nine trusses, each designed to carry the same loading, but of four different combinations of materials and sections, were loaded to failure. Conventional analysis gave a good relative indication of the actual structural efficiency in each case.

By Dr. M. Holmes

Department of Civil Engineering, University of Bristol

OVER the past few years, nine trusses, designed to the same specification for loading and size but of differing materials and sections, have been tested to destruction by the author. Four different designs were involved in all, one using mild steel angles with riveted joints, one using aluminium alloy angles with riveted joints, another special sections of aluminium alloy, and the last cold rolled steel channel sections with welded joints. In this report, the failing loads of the trusses are recorded and compared with the predictions of conventional calculations. Their strength/weight ratios are noted and compared with theoretical predictions given by a straight forward analysis on conventional lines.

All the trusses were designed to have a span of 16 ft and a uniform depth of 2 ft 6 in. Each truss had a design working load of 12 tons, consisting of two 6 ton loads applied at the upper boom at the quarter span points. Alternatively, a working load of 6 tons, applied at the upper boom at one quarter-span point only.

TRUSS DETAILS

All the trusses tested met the above specification, using appropriate conventional methods of design and of manufacture. The four designs concerned were:—

1 Mild Steel Angles.—This truss was an 8-panel Pratt configuration (see Fig. 1), designed in accordance with BS 449, using standard hot rolled angle sections and hot driven rivets.

2 Aluminium Alloy Angles.—This truss was an 8-panel Pratt configuration designed in accordance with the Institution of Structural Engineers' *Report on the Structural Use of Aluminium in Buildings* (1950), and employing standard extruded angle sections (HE 30 WP) and cold driven aluminium alloy rivets.

3 Aluminium Alloy Special Sections.—This truss was also an 8-panel Pratt configuration, and specially designed thin-walled lipped channel and I-sections (HE 30 WP), all extruded, were used for its members. Filled Chobert rivets were used for the joints.

4 Cold Rolled Steel Channels.—This truss was a 4-panel Pratt configuration (see Fig. 2) designed in accordance with the *Cold Rolled Steel Association Manual*, employing standard channel sections formed of mild steel strips with shop welded joints.

LOAD CAPACITY

All the trusses were tested in the Fielding and Platt frame in the engineering laboratory at Bristol University (see ENGNG., p. 817, vol. 182, 28 Dec. 1956). They were simply supported at their ends and laterally stayed at each panel point. Each truss was tested to failure under equal loads applied at the two quarter span points. After failure, tension specimens were cut from the truss members to measure relevant material properties.

The failing loads, expressed as total applied loads, are given in Table I, together with the truss weights. The latter are shown as the total weights for each truss, and an estimate for the weight of the joints involved in each design is given in the fourth column of the table.

TABLE I.—*Failing Loads*

Truss Type	Failing Load, tons	Truss Weight, lb	Estimated Weight of Joints, lb	Mode of Failure
1*a*	31·6	377		Tension
b	31·5	377	41	Tension
2*a** ..	19·7	144		Gusset
b	33·6	146	22	Compression
3*a*	20·4	104		Tension
b	21·1	105	27	Tension
*c** ..	17·6	104		Tension
4*a** ..	26·4	234		Compression
b	30·0	236	10	Compression

* These results are not considered in the comparison of the four designs, for the following reasons:
2*a* was found to have gusset plates thinner than specified.
3*c* was found to have some 50 per cent of its rivets loose.
4*a* was designed with inadequate battening in a main compression member.

A simple method of predicting failing loads has been adopted and applied to all four designs of truss. For the given condition of loading, represented by a force P/2 at each quarter point, the loads in each member were calculated in terms of P, treating the truss as a pin-jointed plane frame. From the forces so determined the axial stresses in the members were obtained by dividing by the net area (across the rivet holes) in the case of the tension members, and by the gross area in the case of the compression members.

Failure of a tension member was then assumed to occur when the axial stress reached the measured ultimate tensile stress for the material, and of a compression member when the axial stress reached the failing value given by the Perry Robertson strut formula. In applying this formula, the yield or 0·1 per cent proof stress was used, and the effective pin-jointed length was taken 0·5L for buckling in the plane of the truss and 0·7L for buckling out of the plane, where L is the length of the member between joint centres (intersections).* (These values would more conventionally be taken as 0·7L and 1·0L respectively, and the results of using the latter values have been noted in brackets in the relevant tables).

* For compression members formed by battening together two component cross sections, failure by one of the cross-sections buckling out of the plane must also be considered. In this case L is the distance between battens.

Some detailed results of this process are given in the tables of Appendix A, but the overall results, compared with the appropriate average test results of Table I, are given in Table II.

TABLE II.—*Comparison of Theoretical and Actual Failing Loads*

Type of Truss	Predicted Result		Test Result	
	Failing Load, tons	Mode of Failure	Failing Load, tons	Mode of Failure
1 ..	30·2	Outermost diagonal in tension	31·6	Outermost diagonal in tension
2 ..	30·0 (28·0)	Top boom in compression out of plane	33·6	Outermost vertical in compression in plane
3 ..	18·4	Outermost diagonal in tension	20·4	Outermost diagonal in tension
4 ..	31·6 (27·2)	Outermost diagonal in compression out of plane	30·0	Outermost diagonal in compression out of plane

It will be seen that the simple calculation process successfully predicts, in three out of the four cases, the mode of failure; and that the predicted failing loads differ from the measured by −5, −11, −10 and +5 per cent respectively.

STRUCTURAL EFFICIENCY

The efficiency of a truss of this kind is commonly measured by the ratio of its load carrying capacity (in this investigation the total failing load) to its total weight. But in order to study that the influence of materials, of form (geometry of the truss and of its members) and of the method of jointing, an analysis of the critical weight of the present type of truss has been developed and is given in Appendix B.

For an 8-panel Pratt truss having the specified depth-to-span ratio, the efficiency ratio is given by

$$\frac{P}{W} = \frac{pp_y(1-k)}{\rho L\{1{\cdot}50p + 1{\cdot}30p_y\}} \quad . \quad . \quad (1)$$

where p = ultimate tensile strength of material.
p_y = yield or 0·1 per cent proof strength of material,
ρ = density of material,
L = span of truss,
k = weight of joints, as fraction of total weight of truss.

For a 4-panel truss of the form of Fig. 2, a similar analysis gives

$$\frac{P}{W} = \frac{pp_y(1-k)}{\rho L\{1{\cdot}50p + 0{\cdot}8p_y\}} \quad . \quad . \quad (2)$$

using the same notation. Comparison of equa-

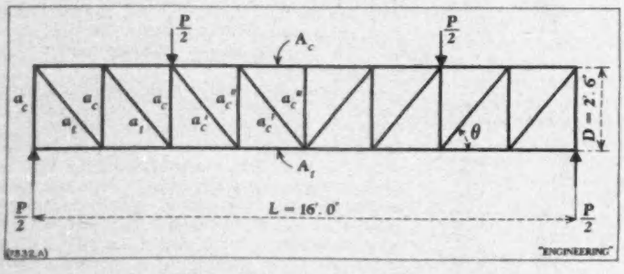


Fig. 1 8-panel truss as used for three of the designs: mild steel angles, light alloy angles and light alloy channel sections.

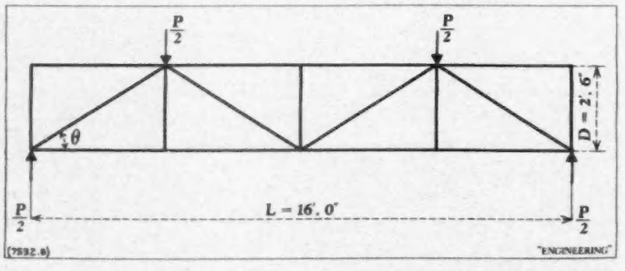


Fig. 2 4-panel truss as used for the design for cold rolled steel sections.

tions (1) and (2) shows that the 4-panel configuration is in this case the more efficient.

The test girders can be considered in the light of these theoretical results. All the relevent data are recorded in Table III.

It will be seen that the theoretical equations (1) and (2) give a very good relative assessment of efficiencies, the actual efficiency in each case being about 0·78 of the theoretical.

It will also be seen that for the two steel designs (1) and (4), the cold rolled section one (No. 4) shows considerable advantage for this light type of truss. Part of this gain is due to the adoption of 4 rather than 8 panels. For the two aluminium alloy designs (2) and (3), the special sections one (No. 3) fails to show any advantage due to the heaviness of its joints.

TABLE III.—*Structural Efficiency of Trusses*

Truss Type	Total Weight (W) lb	Estimated Value of k	Failing Load (F) tons	P/W (lb/lb) Experimental (a)	P/W (lb/lb) Theoretical (b)	Ratio $(a)/(b)$
1	377	0·11	31·6	188	252	0·75
2	146	0·15	33·6	518	665	0·78
3	104	0·26	20·4	444	530	0·83
4	236	0·04	30·0	285	376	0·76

For a truss of the kind specified, the weight of an aluminium alloy truss may be expected to be about 0·4 of that of a corresponding steel one.

In conclusion, I have to make acknowledgment to my colleagues for their help in the work reported here; particularly to Dr. P. Bulson for his design of truss 3, and to Professor Sir Alfred Pugsley for his general guidance. I have also to thank the Aluminium Development Association for supplying trusses 2 and 3, and the Cold Rolled Sections Association for the design and supply of truss 4.

APPENDIX A *Calculation of Failing Loads and Mode of Failure*

TABLE IV.—*Mild Steel—Angle Sections*

Member	Mean axial stress	Limiting stresses, tons per sq. in: Tension	Compression: In plane	Compression: Out of plane	Corresponding value of P for failure, tons: Tension	Compression: In plane	Compression: Out of plane
Compression boom ..	−0·49P	—	15·0 (14·9)	14·8 (14·5)	—	30·7 (30·4)	30·3 (29·5)
Tension boom ..	+0·58P	23·9	—	—	41·2	—	—
Outer ¼ span vertical ..	−0·47P	—	14·7 (13·9)	14·7 (13·7)	—	31·3 (29·6)	31·3 (29·2)
Outer ¼ span diagonal ..	+0·79P	23·9	—	—	30·2	—	—

Theoretical Result.—Failure at 30·2 tons due to tension failure in outer ¼ span diagonal.
Test Result.—Failure at 31·6 tons due to tension failure in outer ¼ span diagonal.

TABLE V.—*Aluminium Alloy—Angle Sections*

Member	Mean axial stress	Limiting stresses, tons per sq. in: Tension	Compression: In plane	Compression: Out of plane	Corresponding value of P for failure, tons: Tension	Compression: In plane	Compression: Out of plane
Compression boom ..	−0·49P	—	15·0 (14·8)	14·7 (13·7)	—	30·5 (30·1)	30·0 (28·0)
Tension boom ..	+0·60P	23·2	—	—	38·7	—	—
Outer ¼ span vertical ..	−0·40P	—	15·0 (14·5)	14·7 (13·6)	—	37·5 (36·2)	36·8 (34·0)
Outer ¼ span diagonal ..	+0·62P	23·2	—	—	37·5	—	—

Theoretical Result.—Failure at 30·0 tons due to buckling out of plane in compression boom.
Test Result.—Failure at 33·6 tons due to buckling in plane in outer ¼ span vertical.

TABLE VI.—*Aluminium Alloy—Special Sections*

Member	Mean axial stress	Limiting stresses, tons per sq. in: Tension	Compression: In plane	Compression: Out of plane	Corresponding value of P for failure, tons: Tension	Compression: In plane	Compression: Out of plane
Compression boom ..	−0·74P	—	15·4 (15·2)	15·5 (15·2)	—	20·8 (20·5)	20·9 (20·5)
Tension boom ..	+0·82P	18·8	—	—	22·9	—	—
Outer ¼ span vertical ..	−0·68P	—	15·0 (14·5)	15·0 (14·4)	—	22·0 (21·4)	22·0 (21·2)
Outer ¼ span diagonal ..	+1·02P	18·8	—	—	18·4	—	—

Theoretical Result.—Failure at 18·4 tons due to tension failure in outer ¼ span diagonal.
Experimental Result.—Failure at 20·4 tons due to tension failure in outer ¼ span diagonal.

TABLE VII.—*Cold Rolled Steel—Channel Sections*

Member	Mean axial stress	Limiting stresses, tons per sq. in: Tension	Compression: In plane	Compression: Out of plane	Corresponding value of P for failure, tons: Tension	Compression: In plane	Compression: Out of plane
Compression boom ..	−0·48P	—	19·3 (18·8)	19·1* (18·4)	—	40·2 (39·2)	39·8* (38·3)
Tension boom ..	+0·65P	23·8	—	—	36·9	—	—
Outer ¼ span diagonal ..	−0·54P	—	19·0 (18·2)	17·1* (14·7)	—	35·0 (33·7)	31·6* (27·2)

Theoretical Result.—Failure at 31·6 tons due to buckling out of plane of outer ¼ span diagonal. A single channel element buckling between battens.
Test Result.—Failure at 30·0 tons due to buckling out of plane of outer ¼ span diagonal. A single channel element buckling between battens.
* These values correspond to a single channel element buckling between battens. For buckling of the composite cross section higher values are obtained for the limiting stresses.

APPENDIX B *Analysis of Theoretical Ratio Failing Load/Dead Weight*

8-Panel Truss.—The boom members are treated as continuous and uniform in cross-section. They are, therefore, designed to withstand the maximum bending moment, giving a member force of $\frac{P\,L}{8\,D}$

The critical loading conditions for the web members in the central half span are compressive forces arising from a shear force of P/8 (i.e., only one quarter span load is applied). In the outer quarter spans the critical loads for vertical and inclined web members are respectively compressive and tensile forces arising from a shear force P/2.

Symbols for the cross-sectional areas of the members required to support these critical loads are given in Fig. 1. The weight of the truss will, therefore, be given by

$$W = \rho\left[L\,(A_c + A_t) + 6\,D a_c + \frac{L}{2\cos\theta}(a_t + a_c') + 3\,D\,a_c''\right]\frac{1}{1-k} \quad (1)$$

where ρ is the density of the truss material, and k is the weight of joints expressed as a fraction of total weight of the truss.

Theoretically the most efficient design will lead to the following conditions being satisfied when the ultimate load P is applied to the truss:

(i) the tension members, by skilful joint design, will be stressed to a value p approaching the ultimate strength of the material.

(ii) the compression members, by design to low slenderness ratios, will be stressed to a value p_y approaching the yield (or proof) stress of the material.

Thus in the ideal case, the following equalities hold

$$p\,A_t = \frac{P\,L}{8\,D} = p_y A_c \qquad p_y a_c = \frac{P}{2},$$

$$p_y a_c' = \frac{P}{8\sin\theta} \qquad p_y a_c'' = \frac{P}{8},$$

$$p\,a_t = \frac{P}{2\sin\theta} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

By substituting equations 2 in equation 1, the following value is obtained for the maximum theoretical load/weight ratio for an 8-panel design:

$$\frac{P}{W} = \frac{16\,pp_y \sin\theta\cos\theta\,(1-k)}{\rho\,L\,[p(17 - 9{\cdot}25\sin^2\theta) + 4\,p_y(5 - 4\sin^2\theta]} \quad . \quad . \quad . \quad (3)$$

For an 8-panel truss with the depth/span ratio specified, equation 3 becomes:

$$\frac{P}{W} = \frac{pp_y(1-k)}{\rho\,L\,[1{\cdot}50\,p + 1{\cdot}30\,p_y]} \quad . \quad (3a)$$

From equations 3 and 3a, it may be seen that the maximum theoretical load/weight ratio (hence the structural efficiency) is inversely proportional to the material density, and varies directly with material strength.

4-Panel Truss.—Applying the above methods to the 4-panel truss, the value for the maximum theoretical load/weight ratio is found to be:

$$\frac{P}{W} = \frac{16\,pp_y \sin\theta\cos\theta\,(1-k)}{\rho\,L\,[p\,(8\cos^2\theta + 5) + 8\,p_y\cos^2\theta]} \quad . \quad . \quad . \quad (4)$$

where the weight of vertical web members, which do not carry any primary stress, has been omitted. For the depth/span ratio specified equation 4 becomes:

$$\frac{P}{W} = \frac{pp_y(1-k)}{\rho\,L\,[1{\cdot}5\,p + 0{\cdot}8\,p_y]} \quad . \quad (4a)$$

Comparison of equations 3a and 4a shows that the 4-panel design is a more efficient structural form than the 8-panel (provided the vertical members in the 4-panel design are light in weight).

Factory Building is a Combined Operation

In planning a new factory no reconnaissance is wasted. But major decisions must be taken as early as possible.

By William G. Beaton

Principal Consultant, Production-Engineering Limited

MANY new factories and industrial buildings cost too much to build. Even when they are built and in running order they often do not meet the true operating needs of the company which owns them or contribute to that company's profits as they should.

The chief reason for this is that too little attention is paid to business needs in designing industrial premises, and to that extent professional practice in this country is incomplete. The industrialist tends to choose an architect or consulting engineer as his principal adviser—and however wide their experience, neither of these can in general be familiar with the purely business considerations involved in the construction of new industrial premises.

There is every reason why this should be so. New factories are usually built only rarely in the lifetime of a company, and it is unlikely that the average client can have the basic training necessary to carry out the fundamental research, and thinking, on which the design of any new factory must be based.

It is in answer to this problem that the industrial and management consultant has entered the field of industrial building. By training and experience he is fitted to carry out the research, and the analysing and synthesising, without which no new factory can be designed, built, and operated efficiently. In collaboration with the architect and other specialists he can establish the correct terms of reference for design work, and achieve both short-term capital and long-term revenue economies in industrial construction work.

What kind of business and management research is necessary before a factory is built?

One of the most important fields of research is that of marketing plans and sales budgets. If it is proposed to sell a million pounds' worth of goods each year, and those goods are to be made in a new factory, then this fact alone will have a decisive effect on the size and design of the new building. Of importance, too, is what might be called product diversification—whether the company proposes to continue making its present range of products, to develop an entirely new range, or some combination of the two. Thus if a company is already making washing machines, and not only wants to continue making these in its new factory but also proposes making refrigerators—then this factor also will have a major influence on the design of the new factory.

Once marketing and sales budget plans have been prepared, and it has been decided what products, and in what quantities, are to be made, then—and only then—is it possible to consider the production capacity and facilities of the new factory.

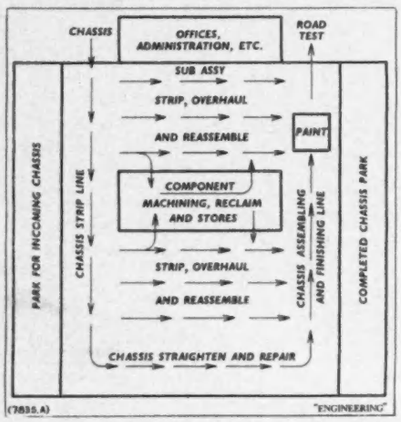
The planning and design of a new factory must also depend a good deal on an analysis of operating costs—on the costs of materials, labour, overheads, as well as on the extent of the profits.

In deciding on the site of the factory—a parallel field of investigation to those already described—questions of distribution and relation to markets will have to be borne in mind, as well as labour requirements, and where labour is available.

These are but a few of the more important matters to be considered before detailed planning can take place. And indeed before the terms of reference of design work are completed it may well be necessary to re-appraise all these factors in relation to each other, not once, but two or three times, before the right answers can be found. Thus a sales budget of £2 millions may be put forward by the sales director. If the implications of this figure are examined it will then be found that this figure presupposes a certain amount of plant, the use of certain handling techniques, and so on; and these in turn add up to certain capital requirements coupled with a certain budgeted level of profit. But it may be that when these capital requirements and potential profits are examined they will be found unacceptable—and it will then be necessary to start all over again.

It should therefore be abundantly clear how necessary it is that some equation should be arrived at between all the factors earlier mentioned before the work of planning and design, let alone building, can go ahead. It is essential to discover which of these factors may be, by implication, odd-man-out as early as possible in the total cycle. These considerations must be analysed before one can get down to the work of designing beams or stanchions or roof trusses.

But once they have been analysed, then it becomes possible for the board of directors of any company to decide, with confidence, on whatever proposals are put forward for new industrial construction work. The saying, time spent on reconnaissance is seldom wasted, which is accepted as a fundamental truth in warfare, is no less true in industry, particularly when on such reconnaissance depends the satisfactory



Flow diagram of Chassis major overhaul workshop minimising material movement.

design and construction of such a permanent capital item as a factory building.

I have been discussing what are in fact the survey and project stages of building a new factory—the survey stage which determines the facts on which all planning work is based; the project phase in which a sufficiently detailed proposition—embracing proposed operating methods and capital and revenue cost estimates—is submitted to make decision by the client company possible. In practice these two stages are followed by the detailed design stage, in which detailed designs and working drawings are prepared which develop the broad proposition already agreed; then by the construction stage, in which the factory is built and equipped; and ultimately by the transfer stage, in which the factory is put into efficient and profitable operation and handed over to the client.

These five, largely self-contained, stages cover the logical development of a job from conception to the time when the building is in full operation. Concerning their implementation, two things are of paramount importance: major decisions must be made as early as possible in the cycle, but only after careful and thorough preliminary planning has taken place; and marked variations in the pattern described must be avoided since most of the difficulties, delays and excess costs which have arisen on any job result from such changes.

Since no project can be regarded as complete until the new factory is operating effectively as a production unit, and since the varied problems involved at all stages from conception to completion require men with varying qualifications and experience to solve them, it is obviously an advantage to the client to make use throughout of the services of a single consulting organisation offering a comprehensive and integrated professional practice. Such an organisation can coordinate the effort of the varied specialist staff required; and indeed the staff includes men who can deal with all aspects of a building project "from the twinkle in the chairman's eye to the opening cocktail party": market specialists, management engineers, management accountants, handling and layout engineers, plant designers, architects, civil engineers, structural engineers, quantity surveyors, services engineers, and draughtsmen. A team of specialists such as these can be made responsible, not only for the survey, project, and detailed design stages of any industrial building project, but also for construction and transfer stages too.

This is an entirely new conception.

In the normal way when a factory is ready to be built, a bill of quantities is prepared and put out to tender with drawings. A contractor is selected, and he contracts to erect the factory to a certain design at a certain cost and within a certain time. Provided that the basic requirements concerning time, cost and quality are satisfied, the way he deploys his plant and labour is his own responsibility. But another approach is possible.

It can be so arranged that the contractor provides labour and materials only, and that the consultant provides a site management service on behalf of the client. In this case the consultant assumes full responsibility for everything that happens on the site—and can, if he wishes, introduce his own methods into the day-to-day building which goes on there.

In the case of a large and complex building job responsibility for the conduct of the whole project throughout all its stages would be vested in a full-time project manager appointed right at the beginning of the survey stage. He would have available a wide range of specialists working on the job either part or whole time according to a carefully prepared master plan. He could for example include an architect in the team in the early stages on a part time basis to help in working out the basic conception, whether it should be a one, two or three-storey building, how laid out, and so on; a management accountant might be represented in the early stages.

The advantages to the client company of a factory planned in the light of business and industrial analytical techniques are considerable. There is first a saving in capital costs which results from building a factory designed according to the principles of good industrial management. There is also the constant yearly saving in operating costs as a result of working in a building designed specifically for the operations which are carried out there. And if the planning, coordination and control of a building project are treated as a combined operation under a project manager on the lines described, then the client company can delegate virtually the whole responsibility for doing a job to one man and his team of specialists rather than to a number of independent advisers. Anyone who has had experience of the traditional approach to building problems in the United Kingdom will appreciate the advantages of this new conception.

Incontri coll'Atomo

AN annual meeting and exhibition of nuclear activities in Italy, "Incontri coll'Atomo," has become a feature of the Milan Fair. This second "encounter with the atom" was organised for interested visitors by the Italian Forum for Nuclear Energy (FIEN). The Forum is an association formed for the purpose of organising meetings and discussions in Italy and participating in international congresses, as well as publicising and popularising the achievements and the prospects of the industry. This year the Italian nuclear "big three," Fiat, Montecatini and Agip Nucleare, were represented at the meeting and it was possible to compare the merits of different approaches to nuclear power in Italy. Advocates of the pressurised, boiling water, organic moderated and gas-cooled reactor types took part in the discussion.

Continued Effort in Fundamental Research

Professor Felice Ippolito, of CNRN, the five-year old Government body supervising nuclear research and development, described the imminent take-over by Euratom of the Italian research centre of Ispra as a vital move, technically linking Italy with the other five members of the Common Market. Italy will continue to participate in fundamental research at the Frascati synchrotron centre and the new laboratories at Casaccia, just outside Rome, which will replace Ispra when the take-over by Euratom is completed. Forty-one per cent of the CNRN expenditure is budgeted for research purposes, but the programmes submitted to the Government last year include much larger outlays. Funds are to be provided by legislation now introduced for Parliamentary approval and being delayed by a prolonged ministerial crisis. If passed, the funds will empower CNRN to give greater assistance to private industry entering the difficult path of nuclear power. The first task will be to improve methods in the operation of the three reactor types now being built for the Italian power stations, the gas-cooled graphite-moderated, pressurised-water and boiling-water types. The second step will be to help Italian industries to build by themselves such nuclear reactors as the country requires, not only the conventional parts as is the case at present. The second generation of Italian nuclear power stations should be 100 per cent home-built.

Organic Moderated Power Prototype

Owing to the present financial arrangements the choice of a reactor suitable for the future requirements of the Italian industries has been limited to one type, the organic-moderated reactor. The decisive factor in the choice of reactor has been American experience which rated first cost of the OMR as the lowest of all the existing types. On 12 January an agreement was signed between CNRN, Agip Nucleare, Fiat and Montecatini for the PRO (Prototype Organic Reactor) project now in progress. A model of PRO was exhibited at the fair. The project will be completely financed by CNRN, designed and developed by Agip Nucleare, and the actual prototype built by SORIN, the company formed by Fiat and Montecatini. At Agip Nucleare the OMR group is in charge of designing the 30 MW(t) prototype. The reactor was described by Professor Gallone, who emphasised its low investment costs chiefly due to the non-corrosive character and low vapour pressure of the polyphenyl moderator-coolant mixture, requiring a moderately thick carbon-steel vessel instead of the usual extra-thick stainless steel plate. The PRO project is intended to supply a wealth of technical and economic information and allow the staff to acquire some experience on how to build and operate larger reactors of this type. In the first phase of the project the core will consist of well-tried elements giving full guarantee against incidents or unexpected results. In the second phase, advanced elements will be used of a type likely to be applied in a future power station. With increased rating, a turbo-alternator might be added in order to operate the plant under conditions closely resembling commercial power generation.

Thorium Cycle and Second Generation GCR

Another important CNRN venture is the uranium-thorium cycle development. The work will be carried out in cooperation with Allis Chalmers and the help of USAEC experience, and the participation of Italian firms such as Bombrini Parodi-Delfino. CNRN will also assist Fiat and Ansaldo in their marine propulsion projects and the material test reactor project of advanced PLUTO type. In gas-cooling, a CNRN scientist, Signor Franco, has been appointed engineer-in-chief of the OEEC Dragon project now in progress at Winfrith Heath. CNRN and Agip Nucleare are already working hand in hand on the plans for the second generation of gas-cooled reactors under the existing agreement between Agip Nucleare and NPPC. The advanced reactors will be based on the development of uranium alloys of low molybdenum and zirconium contents. The CNRN reactor division is also cooperating with Italian industries in connection with the Euratom-USA programme.

Fuel Developments

The Advanced Gas Reactor Group, assisted by British engineers, is studying the feasibility of using tubular elements of higher thermal capacity made of slightly enriched uranium, increasing plant efficiency and reducing costs. The thin section of these tubular elements allows a high power density in the element while keeping the maximum temperatures at a tolerable level The expected average irradiation life of the elements will be 3,000 MWd per tonne. Professor Gallone considers also the possibility of adding molybdenum to alloy uranium, as recent research has proved that higher irradiation levels can thus be achieved. The higher power density makes it possible to reduce the tonnage of the first fuel charge with a corresponding saving in capital investment. Although the coolant temperatures are of the same order as in reactors using unalloyed fuel, it has been possible to improve the steam cycle efficiency to 34 per cent. A further development will be that of studying the possibility of using Latina-produced plutonium as an alternative to uranium 235 enrichment.

Military Activities

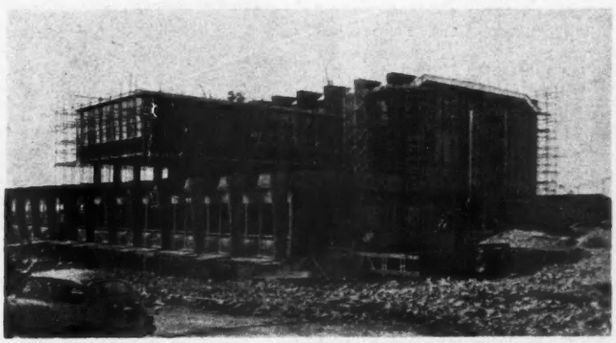
At San Piero a Grado, between Leghorn and Pisa, a group of laboratories is now being built for the reactor operation group of CAMEN (Military Nuclear Energy Allocation Centre) which will include a 5 MW swimming-pool reactor supplied by Babcock and Wilcox Company, which will also serve the nearby Pisa University for research purposes. Signor Mario Carchidio described the project. The reactor has been chosen for its flexibility and safety—the core's MTR-type fuel elements can be set in varied geometries and different flux patterns can be studied. Access to the core is practically unlimited and allows the introduction of new experimental devices during operation. CAMEN is also interested in marine propulsion research, and the Italian Government has entrusted it with the task of coordinating 10 stations for fall-out measurements and 12 stations checking atmospheric radiation.

Marine Projects

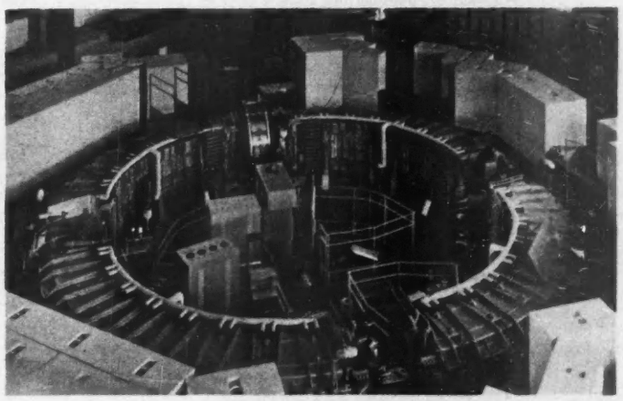
Two speakers, Signor Vacchelli and Signor Zapparo described the atomic-propelled 47,000 ton deadweight (70,000 tons displacement) tanker which has been designed by Fiat-Ansaldo. A "Savannah" type pressurised-water reactor will give the ship a maximum speed of 17 miles per hour, and 2,720 kg of uranium oxide fuel per charge will give a cruising range of 167,000 miles. The reactor's construction will be supervised by Babcock and Wilcox (America), who have a ten-year consulting agreement with Ansaldo's sister firm Cantieri Riuniti dell-Adriatico, Trieste. A model of the ship was exhibited at the atomic display in the fair.

Raw Materials and Fuel Fabrication

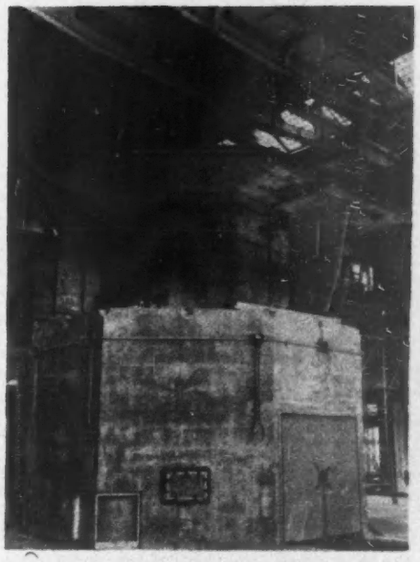
CNRN participates in the search for radioactive minerals in the Italian national territory, some 4,000 sq. km of which have already been explored with promising results. Especially successful was prospecting in the South-Western corner of the Alpine



(Above) The Casaccia research centre is nearing completion.



(Right) For high energy research there is the Frascati synchrotron.



Casaccia's TRIGA Mark II reactor in the final stages of assembly.

belt and in the sandstone Val Gardena area (East-Central Alps). Some 20 to 25 thousand sq. km remain to be prospected and this year mining projects will begin in the Mont Blanc and other Northern Alps districts. About the middle of 1961 the rate of yearly uranium metal production by the Milan metallurgical and industrial chemistry laboratory will reach 130 tons. Samples of the products were exhibited at the fair. Studies are also progressing for the production of refined uranium metal. Signor Giovanni Vacchelli, director of SORIN's technical services, dwelt on the work being carried out at Saluggia, a research centre where Montecatini is working on organic moderators and on chemical plants for production and treatment. The Saluggia Centre will include the ITALATOM plants for the processing of natural, enriched and depleted uranium and thorium. The ITALATOM Company will manufacture and sell at home and abroad complete fuel elements and assemblies. In this venture, Montecatini is in partnership with the Anglo-American Corporation of South Africa, the Engelhart Company of Newark, NJ, and the Malinckrodt Chemical Works of St. Louis, Mo. SORIN is now selling in Italy isotopes produced by the Commissariat Francais de l'Industrie Atomique, but is confident to be able to sell Italian-manufactured isotopes by next October.

Caverns for Vapour Containment

For the last two years the nuclear division of SADE a large electricity generating company, has been training engineers and technicians for nuclear power station design, construction and operation, said Signor Tio Leardini of SADE. Some radioactive and meterological problems are studied and experimental research is carried out on siting nuclear reactors in caverns. The experiments are designed to assess the gas-holding ability of rock formations.

Private Industry Participates

Signor Federico Villa, representing Franco Tosi, a well known heavy engineering factory of Legnano (near Milan), stated that the turbine designed for the SELNI power station will have a rating of 186 MW at 1,500 r.p.m. It will be therefore the world's most powerful turbine constructed so far for a nuclear power station. Tosi is also building the condensation and preheating plants for the SELNI project, the condensation, degasification and feed water preheating plants at Latina's power plant, and the 20 meter 120 ton stainless steel cylindrical body of the SENN steam generator. This kind of plant is usually called "conventional" when built for use in nuclear power stations, but in the case of the SELNI project, the problem of increasing the turbine capacity has been solved by unconventional means. An intermediate resuperheater using live-steam, and a special feed-water preheating cycle are used. Speaking on this subject on 14 April, Signor Franco Castelli, SELNI managing director, said that no further modifications were necessary to achieve the 175 MW actual generation capacity of the power station. Finally, Signor Villa stated that Franco Tosi, following their tradition in the shipping field, are about to start a pressurised-water marine engine project.

Argonaut for Bologna

Professor Sergio Gallone, director of the research and studies of Agip Nucleare at San Donato Milanese, stated that the physics group has completed the design and begun the construction of an intermediate-flux research reactor of the ARGONAUT type to be installed near Bologna, in agreement with Bologna University. The reactor calculation group has carried out for the benefit of the Latina nuclear power station now under construction an analysis of the reactor operations under different conditions, and has tackled some detailed problems such as calculating the levels of carbon dioxide activation. A thorough re-examination of the calculation methods relating to gas-cooled reactors has been carried out in cooperation with NPPC staff. Five-year government and private investment in the Italian nuclear industry is estimated by Professor Ippolito at about £174 million.

Notes and News

General Atomic Licensee in Germany

Following the licence agreement between General Atomic and Vickers-Armstrongs for the manufacture and sale of TRIGA research reactors in the United Kingdom (Atomic Review, 29 Jan. '60), a similar arrangement has now been completed to cover Germany. General Atomic's German choice is Gütehoffnungshütte Sterkrade AG of Oberhausen. The chief difference between the two agreements is that the German firm, in addition to research reactors will have access to the high-temperature gas-cooled reactor designs of the American company, a 40 MW(e) version of which will be constructed at Peach Bottom, Penn. On the basis of the two precedents, it is likely that similar arrangements covering France, Italy and Japan will soon be announced.

Radiation Control May Shift to States in USA

Twenty years after the birth of the nuclear industry the American Government is taking the first steps to decentralise some of its nuclear responsibilities. Under direction from the President, the USAEC, a Federal Agency, has prepared a set of recommendations on the basis of which the responsibility for the control of certain radioactive materials may be transferred to the State Governments. The materials concerned would be nuclear byproducts such as radioisotopes, source materials, and fissile materials of less than a critical mass. Even though decentralisation is the primary aim, the Commission lays great stress on achieving a high degree of uniformity in regulation and control as applied by the State Governments.

Plutonium Recycling and Disarmament

The Hanford plutonium recycle programme "should improve the possibility that plutonium now stored in weapon stockpiles can be used economically for civilian power production," said Donald H. Stewart, assistant director for civilian reactors, USAEC, on 12 April. The American recycle programme is centred on the Hanford facility, where the plutonium recycle test reactor is under construction and will come into operation later this year.

Windscale Separation Plant Contract

Mitchell Construction Company received the contract to erect the main building and ancillary structures for the second plutonium separation plant at Windscale.

Italian-American Fuel Fabrication Project

Under the sponsorship of Montecatini, the chemical giant of Italy, a nuclear fuel processing and fabricating firm, ITALATOMO, has been founded, with Italian, American and South African participation, *Atomo e Industria*, reported recently. The firm will have offices in Milan and a plant in Saluggia, where facilities will be installed for the handling of thorium and uranium of various enrichments, and the fabrication of complete fuel elements. Engineering experience in the handling of nuclear fuels will come from the firm's American associates, Mallincrodt Chemical Works and D. E. Makepeace Division of Engelhard Industries Inc., two of the major fuel fabricators in America. The third associate of Italatomo is the Anglo-American Corporation of South America, producer of raw materials. The Italian consortium is a mirror image of Austro-Chematom, formation of which was reported in Atomic Review, 26 February, 1960. The participants in Austro-Chematom are Oesterreichische Stickstoffwerke AG, a chemical plant, Degussa of Germany, who provide the know-how, and Rio Tinto, with raw material from their Canadian uranium mines.

New Use for Natural Radon

Extremely sensitive counters make it possible to use the minute quantities of radon gas released from the soil as a meteorological tracer. It is estimated that every square mile of soil to a depth of 6 ins contains about one gram of radium, the decay product of which is radon. Argonne's Meteorology Group measured the variation in radon concentration over three 72 hour periods at stations between ground level and 130 ft above ground level and charted the movement of atmospheric pollutants and the periodic variations in air currents.

Search for Beryllium with Boron Trifluoride Counters

Although the fate of beryllium as a reactor material is at present in a state of flux, the high temperature structural qualities of the metal will continue to attract the designer. Electronic equipment can be used for the detection and assaying of beryllium ores in geological surveys. The instrument relies on the detection of neutrons emitted by beryllium when bombarded with gamma rays of suitable energy. The equipment is similar in operation to a Geiger-Muller counter and consists of a tank of oil in which a shielded gamma source and four boron trifluoride counters are suspended. The oil serves both as shield and as neutron moderator. In field use the detector is carried by two persons on 4 ft metal handles to avoid scattered radiation. (S. H. U. Bowie *et al.*: "Electronic Instruments for Detecting and Assaying Beryllium Ores.")

Solid State Ionisation Chamber

Fully transistorised radiation detection instruments will now be possible with a solid state ionisation chamber developed by Hughes Aircraft Company. A slice of doped silicon replaces the gas-filled ionisation chambers. The new instrument is small enough to "fit into the tip of a hypodermic needle." Besides reduction in size, the solid state device should bring transistor reliability to radiation detectors.

New Lease of Life for BEPO

Following the Windscale accident in the production reactors, the undamaged reactor was also shut down as a precautionary measure. To permit continued operation of Harwell's ancient graphite reactor BEPO, which might have been subject to a similar hazard, new instrumentation has been installed.

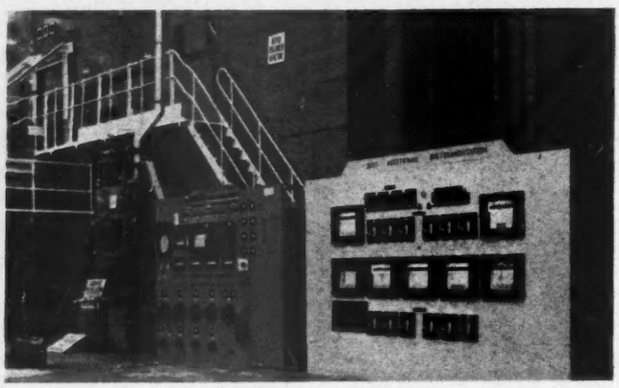


Fig. 4 Graphite temperature of BEPO will be continuously recorded by seven strip-chart multiple pen recorders.

A continuous record of graphite temperature will be made by seven strip-chart multiple-pen recorders supplied by Honeywell Controls. The panel shown in Fig. 4 also has 12 Bailey trip amplifiers.

Reactor Notes

Contractor for Puerto Rico: Maxon Construction of Dayton, Ohio, has been selected as contractor for the Puerto Rico demonstration plant for nuclear superheating. The reactor components were designed by General Nuclear Engineering Corporation of Dunedin, Florida.

Cornerstone for Dragon: Construction of the high-temperature reactor under Project Dragon has been officially inaugurated (on 27 April) by laying the project documents and coins of the founding states into a concrete foundation slab.

More Talk for AGR: Fifty Euratom members are currently discussing problems of the advanced gas cooled reactor with members of the Authority's Risley establishment.

Power from Dresden: Commonwealth Edison's boiling-water reactor at Dresden started to produce power in April. The Dresden plant is the first privately financed nuclear power station.

Experiment for OMR: Construction of the Experimental Organic Cooled Reactor at Idaho was started on 1 May. Phillips Petroleum developed the concept, Atomic International the detailed reactor design, Fluor Corporation provided the architect-engineering services, and C. F. Braun of Alhambra, Calif., will be the contractor.

Discussion for AKS: Discussions have been renewed between the German AKS Group and US-Euratom representatives to save from oblivion the projected 150 MW organic-moderated Stuttgart station.

World Reactor Companies, Associations and Activities

FINAL instalment of ENGINEERING's chart of world reactor companies appears on the pull-out pages below. Previous instalments appeared in the issues of 15 April (ENGNG., vol. 189, p. 522) and 22 April (ENGNG., vol. 189, p. 554). Reprints of the complete chart, and ENGINEERING's small reactor survey with important additions, will be available shortly, price 4*s*.

France, continued

Service Nucleaire St. Gobain

19 Ave. George Clemenceau, Courbevoie, Seine. Nuclear fuels.

Member of Indatom and joint owner with Forges et Ateliers du Creusot of Centre de Recherches pour Combustibles Atomiques.

SICN (Société Industrielle de Combustibles Nucleaires)

Ancy (Savoie). Final preparation and installation of fuel elements.

Members include: Société Alsacienne de Constructions Mécaniques, Aciéries d'Ugine, Compagnie Française des Métaux.

Société Alsacienne de Constructions Mécaniques et Electriques

32 Rue de Lisbonne, Paris 8. Heavy electrical and mechanical engineering.

Member of Framatome, Dynatom, and Groupment Atomique Alsacienne et Atlantique.

Société des Forges et Ateliers de Construction Electriques et Mécaniques Jeumont

5 Place de Rio de Janeiro, Paris 8. Nuclear plant component manufacture.

Member of Framatome, licensee of Westinghouse Electric Corporation.

Société Française des Constructions Babcock et Wilcox

48 rue de la Boétie, Paris 8e. Design and manufacture of pressure vessels and steam generating equipment.

Member of the consortium Indatom, and associated with other members of the Babcock and Wilcox organisation.

Société General de Constructions Electriques et Mécaniques Alsthom

38 Avenue Kleber, Paris 8. Complete nuclear power plants based on General Electric boiling-water reactors.

Member of Framatome. Associated with General Electric Company (US).

Société Industrielle de Combustible Nucleaire

68 Rue de Monceau, Paris 8. Supply fuel for the reactors G1, G2, G3, EL2, EDF-1 and EDF-2.

SODERN (Société Anonyme d'Etudes et Realisations Nucleaires)

10 rue de la Passerelle, Suresnes (Seine). Control room equipment; shielded thermocouples.

SRTI (Société des Recherches Techniques et Industrielles)

111 rue de la Boétie, Paris 8. Consultants to the Commissariat de l'Energie Atomique.

Members include: Rateau, Aciéries d'Ugine, Compagnie Générale de Télégraphie sans Fil.

Germany

Allgemeine Elektrizitäts-Gesellschaft (AEG)

Frankfurt-am-Main, Germany. Power and marine reactor construction, boiling water and heavy-water moderated reactor studies, marine propulsion.

Associated with General Electric Company (US) and Hochtief AG for land-based power stations, and with Deutsche Werft for marine propulsion.

Arbeitsgemeinschaft Brown Boveri-Krupp

Created specifically for the development of high-temperature gas-cooled reactors, currently the consortium is constructing a 16 MW(e) prototype at Julich, Germany.

Consortium of Brown, Boveri und Cie AG and Friedrich Krupp AG

Brown Boveri und Cie. A.G.

Mannheim 1, Germany. Design and fabrication of complete reactor stations, power plants, mechanical handling equipment, electrical machinery, control and switchgear, particle accelerators, instrumentation. Gas-cooled marine reactor development in collaboration with AG Weser and Friedrich Krupp.

Member of Arbeitsgemeinshaft Brown, Boveri—Krupp, associated with AG Weser for marine reactor applications, and with other members of the Brown, Boveri organisation. Associated in 1958 with Mitchell Engineering and General Nuclear Engineering for German power station tenders.

Degussa AG

Frankfurt, Germany. Fuel production and fabrication, nuclear materials, chemical processing.

Associated with Austro—Chematom, the Sumitomo Atomic Energy Group and the Mitsubishi Atomic Power Industries.

Demag AG

Duisburg. Heavy engineering.

Member of Interatom.

Deutsche Babcock and Wilcox Dampfkesselwerke AG

Oberhausen, Rheinland, Germany. Design studies of gas-cooled graphite-moderated reactor systems, civil engineering subcontractors for the Hamburg and Karlsruhe research reactors, supply of reactor components and auxiliaries, heat exchangers and experimental loops.

Associated with other members of the Babcock and Wilcox organisation, in particular Babcock and Wilcox Company of New York and Babcock and Wilcox Ltd. of London.

Friedrich Krupp AG

Essen, Germany. Design and fabrication of pressure vessels and heavy engineering components, supply of special steels, steel erection and civil engineering.

Member of the Arbeitsgemeinshaft Brown, Boveri—Krupp, associated with AG Weser for marine reactor applications.

Gesellschaft für Kernenergieverwertung in Schiffbau und Schifffahrt

Geesthacht, Hamburg, Germany. Research and development of marine propulsion plants. Operate a 5 MW research reactor, purchased the 16,000 ton tanker Esso Bolivar for conversion to a floating testbed for marine reactors, to be fitted with an organic-moderated reactor supplied by Interatom.

Subsidiary organisation of the Gesellschaft zur Forderung der Kernenergieverwertung in Schiffbau und Schifffahrt, an association of shipowners, shipyards, banks and insurance companies.

Gutehoffnungshutte Sterkrade AG

Oberhausen. Detail design and manufacture of high-temperature gas-cooled reactors and TRIGA research reactors.

Associated with General Atomic, with exclusive manufacturing and sales rights in Germany.

Interatom GmbH

Altes Schloss, Bensberg-Köln. Organic-moderated land-based power stations and marine propulsion reactors, Atomics International L-series research reactors, and reactor instrumentation.

International consortium comprising Atomics International and Demag AG.

Maschinenfabrik Augsburg-Nurnberg AG

Werk Nurnberg, Nurnberg 2, Germany. Construction of gas-cooled graphite-moderated reactor stations to GEC—Simon-Carves design; design and construction of steam generating plant, steam turbines and heavy machinery; developed special neutron diffraction equipment for experimental purposes.

Associated with General Electric Company Ltd. of England.

Pintsch Bamag AG

PO Box 11, Putzbach, Germany. Chemical processes, nuclear materials, heavy-water production, Argonaut based research reactors.

Siemens-Schuckertwerke AG

Berlin-Erlangen, Germany. Joint tenders with Westinghouse for German power station contracts. Design and construction of Argonaut based research reactors. Heavy-water moderated power reactor studies.

Associated with Westinghouse Electric Corporation for land-based power stations and Howaldt AG for marine propulsion studies.

Israel

Isratom (Israel Nuclear Engineering Company)

c/o Israel Fuel Corporation Ltd., 6 Ahuzat Bayit Street, Tel Aviv. Studies of industrial applications of nuclear energy.

Company formed by Israel Fuel Corporation (DELEK).

Italy

AGIP Nucleare

Galleria Passarella, Milan. Created for the implementation of a 10 year nuclear power programme. First station is constructed by the Nuclear Power Plant Company at Latina.

Fully owned subsidiary of the Italian state agency ENI, controlling interest in Societa Italiana Meridionale per l'Energia Atomica (SIMEA).

Ansaldo

Via Mura, Genoa. Marine architecture for nuclear ships.

Shipyard, associated with Fiat in the application of nuclear power to ship propulsion.

Cantieri Riuniti Dell' Adriatico

Trieste. Naval architecture and shipbuilding.

Associated with Babcock and Wilcox Company of New York for nuclear marine propulsion.

Fiat, Sezione Energia Nucleare

Corso G. Marconi, Torino. Design of nuclear power stations and components, ship reactors.

Associated with Montecatini in forming Societa Richerche Impianti Nucleari for nuclear research. Associated with Westinghouse Electric Corporation for Italian power projects, and with Ansaldo for nuclear ship propulsion.

Franco Tosi

Corso Italia 27, Legnano, Milan. Power reactor component manufacture, pressurised water reactors.

Italatomo

Milan. Chemical extraction and purification of thorium and uranium, fuel fabrication.

Sponsored by Montecatini, and associated with Anglo-American Corporation of South Africa, Engelhard Industries Inc. of Newark, N.J., and Mallincrodt Nuclear Corp. of St. Louis, Mo.

General Nuclear Engineering Company

Dunedin, Florida.

Since January, 1959, a division of Combustion Engineering.

Nuclear superheat, boiling superheat and gas-cooled reactor studies.

H.K. Ferguson Company

11th Street, Cleveland 14, Ohio.

Architect-engineers, designed and built the 20 MW(t) Brookhaven Research Reactor.

High Temperature Reactor Development Associates Inc.

Association of 40 privately owned utility companies in the United States under the sponsorship of Philadelphia Electric Company. Associated with General Atomic (reactor), Bechtel Corporation (architect-engineers) and Westinghouse Electric (conventional plant).

Development of high-temperature gas-cooled power reactors.

Internuclear Company

Clayton 5, Missouri.

International consulting services, develop flux trap concept for advanced material testing reactors.

Isbrandtsen-Maryland Shipbuilding-Ford Instruments Group

c/o Isbrandtsen Company Inc., 26 Broadway, New York 4.
Association of Isbrandtsen Company, the Maryland Shipbuilding and Drydock Company, and Ford Instrument Division of Sperry Rand Corporation.

Development of advanced gas-cooled reactor for marine propulsion

Kaiser Engineers

Oakland 12, California.

Division of Henry J. Kaiser Company. Formerly associated with ACF Industries. Associated with Westinghouse Corporation. Associated with C. Itoh and Company of Osaka, Japan.

Architect-engineers. With ACF Industries developed gas-cooled graphite-moderated reactors, proposed hydrogen-cooled reactors, study military nuclear power applications, principal contractors for the experimental prototype gas-cooled reactor of the Oak Ridge National Laboratory, and the 175 MW(t) engineering test reactor for the Idaho testing station of the USAEC.

Lockheed Nuclear Products

3272 Peachtree Road, Atlanta 5, Ga.

Subsidiary of Lockheed Aircraft, Acquired Puget Sound Bridge for future submarine contracting. Associated with Stearns-Roger Mfg. Co. and American Hydrotherm Co. for portable nuclear plant development.

Supplied 10 kW pool reactor to Ohio State University, and 10 MW tank radiation effects reactor to the US Air Force. Nuclear powered bomber studies. Developed air-liftable pressurised-water plant of 1 MW(e) power, and portable pool reactors.

Mallincrodt Nuclear Corporation

St. Louis 7, Mo.

Nuclear fuels.

The Marquardt Corporation

16555 Saticoy Street, Van Nuys, California.

Development of portable and propulsion reactor concepts, prime contractor for the development of nuclear ram-jet engine under Project Pluto.

Martin Nuclear

Baltimore 3, Maryland.

Division of Martin Company.

Develop PM-1 air-transportable pressurised-water power plant for US Army, nuclear auxiliary power systems for space flight using radioactive isotopes, and develop the liquid fluidised-bed reactor concept. Operate a zero-power test facility, and fabricate fuel elements for the Elk River boiling-water reactor.

M & C Nuclear Inc.

PO Box 898, Attleboro, Mass.

Formerly a subsidiary of Metals and Controls Corporation, now a division of the Texas Instruments Inc.

Fuel and reactor-core fabrication.

National Lead Company

New York, NY.

Nuclear fuel fabrication and chemical processing, metallic or oxide, all enrichments.

Norton Company

Worcester, Mass.

Nuclear fuel fabrication, unclad oxides.

Nuclear Development Corporation of America

5 New Street, White Plains, N Y.

Associated with Sargent and Lundy in heavy-water moderated reactor development. Associated with Belgonucleaire for research and development. European branch NDA Europe, 31 Rue du Marais, Brussels. Associated with Assaldo of Italy for research into fog-cooled reactors. Collaborate with Curtiss-Wright, General Electric, General Motors, in military power plant development.

Heavy-water reactor development, including steam-cooled versions, supplied 10 kW research reactor to Tennessee University, zero-energy reactor for the Pawling Research Centre, designed the Belgian material testing reactor BR-2 at Mol.

Nuclear Materials and Equipment Corporation (NUMEC)

Apollo, Pa.

Nuclear fuel fabrication and chemical processing, metallic, carbide or oxide, all enrichments.

Nuclear Metals Inc.

Cambridge, Mass.

Nuclear fuel fabrication, metallic, metal alloys, cermets.

Nuclear Power Group

Consortium of seven public utilities and the Bechtel Corporation. Sponsors of the Dresden power station. Associated with Atomics International for studies of boiling and superheating graphite-moderated reactors.

Research organisation.

Phillips Petroleum Company

Bartlesville, Okla.

Principal contractors for the special power excursion reactor test series (SPERT 1 to 4) to the USAEC.

Power Reactor Development Corporation

c/o Detroit Edison, Detroit, Michigan.

Non-profit organisation of 26 public utility companies and industrial concerns created for the development and operation of fast-breeder reactors. Associated with Atomic Power Development Association Inc.

Development and operation of the 100 MW(e) Enrico Fermi fast-breeder reactor.

Pratt and Whitney Aircraft Division

East Hartford, Conn.

Division of United Aircraft Corporation.

Develop indirect-cycle nuclear aircraft engines

Rocky Mountain—Pacific Nuclear Research Group

Association of privately owned utility companies in the North-Western part of the United States, many also members of High Temperature Reactor Development Associates. Associated with General Atomic.

Preliminary studies for high-temperature gas cooled power reactors.

Sanderson and Porter

52 William Street, New York 5, N Y.

Associated with Alco Products Ltd.

Development of high-temperature pebble bed reactors.

Sandia Corporation

Sandia Base, New Mexico.

Subsidiary of Western Electric Incorporated.

Designed, own and operate the 5 MW(t) tank Sandia Engineering Reactor Facility.

Sargent and Lundy

140 S. Dearborn Street, Chicago.

Associated with Nuclear Development Corporation of America.

Development of heavy-water moderated pressure-tube reactors, process head reactors.

Shattuck Chemical Company

Denver, Colorado.

Chemical extraction and purification of uranium and thorium.

Stone and Webster

90 Broad Street, New York 4, N Y.

Associated with Combustion Engineering.

Development of pressurised-water reactors and associated plant.

Sylvania-Corning Nuclear Corporation

PO Box 59, Bayside, N Y.

Joint owner with Compagnie de St. Gobain, Pechiney, and Forge et Atelier Creusot of Centre de Recherche pour Combustible Atomique.

Nuclear fuel fabrication.

Thor-Westcliffe Development, Inc.

Sante Fe, New Mexico.

Uranium separation by multi-stage gas centrifuge.

Vitro Engineering Company

261 Madison Avenue, New York, N Y.

Division of Vitro Corporation of America. European branch is Vitro International, Geneva, Italian subsidiary Vitro Italiana SA, Milan. Mining interest associated with Rockester and Pittsburgh Coal Company, and amalgamated with Heavy Minerals Company. Merged with Refinery Engineering Company of Tulsa, Oklahoma.

Extensive uranium mining interests. Developed simple temperature-controlled research reactor which achieves criticality only when cooled below 65° F. Supplied a 10 kW dual core pool reactor to Cornell University. Consultants to SIMEA, Italy.

Westinghouse Electric Corporation

PO Box 2278, Pittsburgh 30, Pa.

Associated with Mitsubishi and the Mitsubishi Atomic Power Industry Consortium in Japan, Siemens-Schuckerwerke AG in Germany, Ateliers de Constructions Electriques de Charleroi (ACEC) in Belgium, Fiat in Italy, and Framatom in France. Operate the Bettis Atomic Power Laboratory under contract to the USAEC. Agents for Aerojet General Nucleonics research reactors outside USA. International agents are Westinghouse International Atomic Power Company, Geneva.

Developed the pressurised-water reactor for submarine propulsion, received contracts for over forty plants including eight reactors for the aircraft carrier Enterprise, two for the guided missile cruiser Long Beach, and the propulsion plant for HMS Dreadnought. Land-based version of the submarine reactor developed for the 60 MW(e) Shippingport station. Further reactors supplied for Mol, Belgium (12·5 MW(e)), Yankee Atomic Electric Co., Rowe, Mass. (134 MW(e)), and Edison-Volta, Italy (165 MW(e)). A 5 MW(e) pressurised water reactor is supplied for General Public Utilities Corporation, Saxton, Penn. and a 17 MW(e) pressurised heavy-water reactor for Carolinas-Virginia Nuclear Power Associates. Built and operate the 20 MW(t) Westinghouse test reactor.

United States of America

ACF Industries

Assets, projects, personnel and goodwill taken over by Allis-Chalmers Manufacturing Company in June, 1959.

Prior to June 1959 developed indirect-cycle boiling-water reactors, gas-cooled reactors and material-testing reactors.

Aerojet-General Nucleonics

PO Box 77, San Ramon, California.

Subsidiary of Aerojet-General Corporation. European agents: Laboratoires Derveaux, Paris. Westinghouse Electric Corporation are agents for Aerojet-General research reactors outside USA.

Prime contractor for US Army gas-cooled reactor programme, operates the gas-turbine reactor test facility, Fort Belvoir, and the gas-cooled reactor experiment at the Idaho testing station. Developed ML-1 nitrogen-cooled water-moderated reactor. Developed the AGN-201 and AGN-211 series of solid-homogeneous zero-power research and training reactor of which over 30 heave been built. Build the 10 MW Aerojet nuclear testing reactor. Develop boiling-sulphur reactor.

Alco Products, Incorporated

Schenectady, NY.

Formerly associated with Humphreys and Glasgow, London. Associated with Sanderson and Porter in high-temperature reactor development.

Develop pressurised-water air-transportable power plants for the US Army, operates SM-1 and builds SM-1A, SM-2 and PM-2A prototype plants. Design studies of gas-cooled and pressurised-water commercial stations. Supplied to Westinghouse the pressuriser for the Belgian BR-3 reactor, and components for the Argonne low-power reactor. Develop high-temperature pebble-bed reactor with Sanderson and Porter.

Allis-Chalmers Manufacturing Company

508 Kennedy Street, Washington 11, DC.

Integrated light and heavy engineering concern. In June 1959 acquired the assets, projects, personnel and goodwill of ACF industries; and Commercial Nuclear Reactor Engineering, office of Nuclear Products Ltd.

Develop the direct and indirect cycle boiling-water reactors. Construct the 22·5 MW(e) Elk River and the 66 MW(e) Sioux Falls plants. Supplied high-power research reactors from 1 to 30 MW(t) to Massachusetts Institute of Technology; Ispra, Italy; Petten, Netherlands; and Studsvik, Sweden.

American Lava Corporation

Subsidiary of Minnesota Mining and Manufacturing Company.

Nuclear fuel chemical processing, metallic, carbide or oxide, all enrichments.

American Standard Corporation

8111 Tireman Arc., Dearborn, Mich.

Develop mercury-cooled and variable-moderated reactor concepts for the USAEC. Developed Argonaut based research and training reactor, sold one each to Iowa State University and Virginia Polytechnic Institute.

AMF Atomics

140 Greenwich Avenue, Greenwich, Conn.

Division of American Machine and Foundry Company. Associated with Mitchell Engineering, UK, on boiling-water power and propulsion plants. Associated with Mitchell Engineering and General Nuclear Engineering in bidding for an Italian power station contract.

Supplied large number of pool research reactors and the 10 MW(t) heavy-water reactor JRR-2 for Japan. A power project for Cuba, although in advanced stage of negotiations, is now in jeopardy.

Arthur D. Little Inc.

Cambridge, Mass.

Independent research and development laboratory.

In January, 1960, acquired patent rights to the Daniels-Boyd high-temperature gas-cooled reactor design.

Atomic Power Development Associates

1911 First Street, Detroit 26, Michigan.

Non-profit organisation with largely the same membership as Power Reactor Development Corporation, set up to perform necessary experiments and design the Enrico Fermi fast-breeder plant. Concluded an exchange agreement with the UKAEA on fast-breeder reactors.

Design and testing of the 100 MW(e) Enrico Fermi fast-breeder reactor.

Atomics International

PO Box 309, Canoga Park, California.

Nuclear division of North American Aviation Inc. Affiliated with Interatom, Germany; and Dynatom, France. Associated with English Electric of UK and ASEA of Sweden in application of organic-moderated reactors. Associated with Bechtel Corporation, USA and Montecatini, Italy, in bidding for Italian power station contracts. Associated with the Fluor Corporation, USA, for reactor construction in the United States. Acquired nuclear projects of Foster Wheeler.

Developed the L-series of aqueous-homogeneous research reactors, of which seven have been sold in the 2 to 100 kW(t) range. Power reactor activities centre on the organic moderated, sodium-cooled graphite-moderated, and the boiling-water cooled graphite-moderated superheat reactor. Under construction are the 12·5 MW(e) Piqua City OMR, the 75 MW(e) Hallam SGR, and a 150 MW(e) OMR is projected for Stuttgart, Germany. Completed design studies of organic-moderated ship reactors, and studies the epithermal thorium reactor concept. Developed nuclear auxiliary power systems for space travel.

Babcock and Wilcox Company

161 East 42nd Street, New York 17, New York.

Associated with other members of the Babcock and Wilcox organisation, e.g. Babcock and Wilcox Ltd., London, and Deutsche Babcock and Wilcox Dampfkesselwerke AG. Associated with Cantieri Riuniti dell Adriatico of Trieste for nuclear ship propulsion in Italy. Associated with Indatom in nuclear research under US-Euratom sponsorship. Associated with H. K. Ferguson Co., architect-engineers.

Design and manufacture of complete reactors, power stations, or major components, prime contractors for the 275 MW(e) Indian Point station and the propulsion plant for NS Savannah, design studies for liquid-fuel and gaseous-suspension systems, design and manufacture of pool research and test reactors from zero to 5 MW(t) power, fabrication of pressure vessels, pressurisers, steam generating plant and associated equipment, and fabrication of enriched fuel elements.

Bechtel Corporation

220 Bush Street, San Francisco 4, California.

Associated with Atomics International in the development of organic-moderated reactors and bidding for Italian power station contracts. Associated with General Atomic on high-temperature reactor project for Peach Bottom. Members of the Nuclear Power Group (America).

Architect-engineering services.

Bendix Corporation

3130 Wasson Road, Cincinnati, Ohio.

Supplied 10 kW tank research reactor to the University of Kansas. Reactor instrumentation, control rods, nuclear aircraft engines.

Clevite Company

Cleveland, Ohio.

Nuclear fuel fabrication, metallic or oxide, all enrichments.

Combustion Engineering Inc.

200 Madison Avenue, New York 16, NY.

Acquired the assets, projects, personnel and goodwill of General Nuclear Engineering Corporation in January, 1959. Associated with Stone and Webster Engineering Corp. and member of the Mitchell—Fairfield—Combustion Engineering nuclear power consortium.

Supply pressurised-water reactor for US Navy submarine; pressurised-water reactor study for nuclear tanker, construct the Nuclear Test Plant for the USAEC for testing power-reactor cores; develop boiling-water reactors with and without nuclear superheat for marine and land-based applications, and develop gas-cooled heavy-water moderated pressure-tube reactors for the East Central and the Florida West Coast nuclear groups.

Convair Division

San Diego 12, California.

Division of General Dynamics Corporation. Associated with General Electric in nuclear powered aircraft development.

Nuclear aircraft airframe studies, constructed the aircraft ground test and the aircraft shield test reactors, the latter was airborne by a B-36 bomber of the USAF. Nuclear bomber studies.

Curtiss-Wright Corporation

Wood-Ridge, New Jersey.

Acquired Isotope Products Ltd. in 1958, to operate as Canadian Curtiss-Wright Ltd. Co-operate with General Electric, General Motors and Nuclear Development Corporation.

Supply pool research reactors from zero to 4 MW(t) power, develop compact military power plants for the US Army. Heavy-water critical and subcritical facilities, process-heat reactor studies.

Davison Chemical Company

Baltimore, Maryland.

Division of W. R. Grace and Company.

Nuclear fuel fabrication and chemical processing, metallic or oxide, all enrichments.

Daystrom Inc.

PO Box 347, West Caldwell, NJ.

Supplied Brookhaven Medical Research Reactor. Develop Argonaut based research and training reactors.

D. E. Makepeace Company

Attleboro, Mass.

Division of Engelhard Industries Inc.

Nuclear fuel fabrication, alloys and dispersions.

Ebasco Services

2 Rector Street, New York, NY.

Associated with General Electric.

Architect-engineers, responsible for General Electric boiling-water reactor construction in the United States and Italy.

E.I. Du Pont de Nemours and Company

Wilmington 98, Delaware.

Design of graphite and heavy-water plutonium production reactors for Hanford and Savannah River, operators of the Savannah River plutonium plant under contract to the USAEC, design low power test reactors for Hanford and Savannah River. Develop heavy-water power reactors.

Fluor Corporation

12000E Washington Boulevard, Whittier, Calif.

Associated with Atomics International.

Architect-engineers for the experimental organic-moderated and cooled reactor. Principal contractors for the 40 MW material-testing reactor for the Idaho Testing Station.

Foster Wheeler Corporation

Nuclear interests acquired by North American Aviation in May, 1959.

Supplied tank research reactors to the Livermore Laboratories, California (1 MW) and the Danish research centre at Riso (5 MW).

General Atomic

PO Box 608, San Diego 12, California.

Division of General Dynamics Corporation. Licence agreement with Vickers-Armstrongs (Aircraft) Ltd. concerning TRIGA research reactors. Associated with other members of General Dynamics, in particular the Electric Boat Division for nuclear submarine studies. Associated with Bechtel Corporation on high-temperature reactor project for Peach Bottom. Associated with Gutehoffnungshutte Sterkrade AG of Germany for manufacture of high-temperature power and TRIGA research reactors.

Designer and manufacturer of TRIGA research and training reactors of which 15 have been sold. Principal American advocate of gas cooling for power stations and marine propulsion. Prime contractors for the 30 to 40 MW(e) Peach Bottom station, and develops closed-cycle gas-turbine reactors operating on helium collant and beryllium-oxide moderator. Design contract for nuclear space propulsion project Orion.

General Electric Company, Atomic Power Equipment Department

San Jose, California.

Associated with other members of the General Electric Company. Export contracts handled by the International General Electric Company of Geneva. Associated with Mitsui Company and the Nippon Atomic Energy Industry Company in Japan, with Allgemeine Elektrizitats Gesellschaft, in Germany, Suisatom SA in Switzerland, and Alsthom of France. Operate the Knolls Atomic Power Laboratory for USAEC. Associated with Ebasco Services for the Punta Fiume power-station contract. Associated with Convair nuclear aircraft projects. Associated with Curtiss-Wright, General Motors and Nuclear Development Corporation for military power plant development.

Developed the boiling-water reactor concept and contracted to supply reactors for the 180 MW(e) Dresden, 70 MW(e) Humboldt Bay, 50 MW(e) Big Rock Point, and 230 MW(e) Punta Fiume (Italy) stations. In addition supply power demonstration stations for GE's Vallecitos laboratories, Japan and Germany. Supplied one 20 MW(t) tank, and seven low-power pool research reactors. Supplied sodium-cooled reactor for the submarine Seawolf (later dismantled), and advanced pressurised-water reactors for Triton and the guided-missile destroyer Bainbridge. Designed six graphite-moderated plutonium-production reactors for the Hanford Plant. Develop direct-cycle aircraft propulsion plants. Operate the 20 MW(t) General Electric test reactor at Vallecitos, California. Supplied seven pool research reactors.

Atomic Review

Montecatini

Via Turati 18, Milan.

Chemicals, chemical plant, nuclear fuel fabrication and irradiated fuel processing.

Associated with Fiat in forming Societa Richerche Impianti Nucleari for nuclear research. Associated with Atomics International and Bechtel Corporation in bidding for Italian power station contracts. Sponsor of Italatomo, Milan.

Societa Elettronucleare Italiana (SELNI)

c/o Societa Edison, Foro Buonaparte, Milan.

Construction of a 160 MW(e) pressurised-water reactor supplied by Westinghouse for Northern Italy.

Organisation for the promotion of nuclear power in Italy, 55 per cent owned by Edison Volta, 15 per cent by Finelettrica, and 30 per cent by private companies.

Societa Elettronucleare Nazionale (SENN)

Via Savoia, Rome.

Construction of a 230 MW(e) boiling-water reactor supplied by General Electric Company (US) for Punta Fiume.

Organisation for the promotion of nuclear power in Italy, 90 per cent state controlled and 15 per cent private.

Societa Italiana Meridionale per l'Energia Atomica (SIMEA)

c/o Agip Nucleare.

Construction of nuclear power plants.

Organisation for the promotion of nuclear power in Italy, 75 per cent owned by Agip Nucleare, and 25 per cent by Finelettrica.

Societa Richerche Impianti Nucleari (SoRIN)

Via Turati, Milan.

Nuclear research and reactor design. Operate the 1 to 5 MW Avogadro research reactor supplied by AMF.

Association of Montecatini and Fiat.

Japan

First Atomic Power Industry Group (FAPIG)

c/o Fuji Electric Manufacturing Co. Ltd. 6, 2-chome Marunouchi, Chiyoda-Ku, Tokyo.

Revised Calder Hall type reactors, boiling-water and pressurised-water reactor studies, gas-turbine cycles. Contractors in the construction of the Tokai Mura power station.

Consortium based on the Fuji Electric-Kawasaki Heavy Industries Association and comprises: Furukawa Electric Co., Kawasaki Steel, Kobe Steel, Asahi Electro-Chemical, Dai-Ichi Bank, Ebara Mfg. Co., Fuji Electric Mfg., Nippon Fire and Marine Insurance, Nippon Light Metal, Nissho Co., Shibusawa Warehouse Co., Ube Industries Ltd., Yokohama Rubber Co. Also associated with GEC—Simon-Carves.

Japan Atomic Power Company

1-4 Otemachi, Chiyoda-ku, Tokyo.

Power station construction and operation.

Operating company created for the implementation of the Japanese nuclear power programme. Interest is shared by the Government (20 per cent), the nine regional public utility companies (40 per cent) and the Japanese heavy industries (40 per cent). Associated with the Nissho Company, who act as import agents.

Mitsubishi Atomic Power Industries Inc. (MAPI)

Otemachi Bldg., 4, 1-chome, Otemachi, Chiyoda-ku, Tokyo.

With the technical assistance of AMF Atomics built the JRR-2 (CP-5) reactor. Have also designed the first all-Japanese reactor JRR-3. Calloborates with Westinghouse on a 10 MW test reactor. Collaborates with AEI-John Thompson on gas-cooled reactors. A final agreement with Westinghouse for technical collaboration is soon expected to be signed. Negotitations are under way with Degussa on fuel fabrication for Calder Hall type reactors.

Comprises all Mitsubishi controlled companies plus: Asahi Glass, Tokio Marine and Fire Ins., Meiji Mutual Life Ins., Nippon Yusen Kaisha, Dainishi Electric Wire and Cable.

Nippon Atomic Industry Group (NAIG)

c/o Mitsui Ltd.

Design and construction of complete reactor stations, marine propulsion reactors, and research reactors.

Established by the Mitsui and Tokyo Shibaura (Toshiba) Group of Companies, comprising: Taizo Ishizaka, Ishikawa jima-Shibaura Turbine, Taiyo Dengyo, Ishikawajima Heavy Industries, Taisho Marine and Fire, Nippon Carbon, Takenaka Komute, Nippon Metal Industries, Dainippon Celluloid, Nippon Juryu Kogyo, Okano Valve Mfg., Japan Steel Works, Onoda Cement, Nishimatsu Construction, Fujikura Cable Works, Hokkaido Colliery and Steamship, Electro Chemical Industrial, Toyo Rayon, Sanki Engineering, Toyo Soda, Miike Synthetic Industry, Tokyo Fiber, Mitsui Chemical Industry, Toyo Koatsu Industries, Mitsui Shipbuilding and Engineering, Toyo Carrier Engineering, Tokyo Shibaura (Toshiba) Electric, Tokushu Seiko, Yokogawa Electric Mfg., Showa Electric Wire and Cable, Showa Aircraft, Shimizu Construction.
Foreign affiliations: General Electric (US), Chicago Bridge and Iron, Foster Wheeler, Ebasco Service Company.

Sumitomo Atomic Energy Group (SAEG)

22, 5-chome, Kitahama, Higashi-ku, Osaka, Japan.

Design and construction of power stations, components, chemical plant, research facilities and accelerators.

Consortium centred around the Sumitomo Group of companies, and includes also: Osaka Kinzoku Kogyo, Osaka Titanium Co., Kanto Special Steel Works, New Nippon Electric Co., Nikken Sekkei Kohmu Co., Nissin Electric Co., Nippon Safety Glass Co., Nippon Stainless Steel Co., Nippon Glass Fibre Co., Besshi Construction Co., Befu Chemical Co.

Tokyo Atomic Industrial Consortium (TAIC)

Otemachi Building, 4, 1-chome, Otemachi, Chiyoda-ku, Tokyo.

Develop liquid-metal cooled reactors, ship propulsion reactors, power plant components, chemical plant, nuclear materials.

Consortium of 22 companies centred on the Hitachi Group and comprising: Hitachi Heavy Engineering, Showa Denko Chemicals, Ashi Chemical Industries, Japan Oxygen, Kajima Construction, Teikoku Rayon, Marubeni-Iida, Nippon Mining, Toa Nenryo Kogyo KK, Nippon Yakin Kogyo Co., Nihon Cement Co., Nissan Chemical, Tokyo Rope Mfg. Co., Nippon Reizo KK, Nippon Suisan Kaisha, Nippon Breweries, The Fuji Bank, The Sanwa Bank, Nippon Oils and Fats, The Nissan Fire and Marine Ins., The Yasuda Fire and Marine Ins., The Koa Fire and Marine Ins. Co., Maruzen Oil Co.

Netherlands

Neeratom

Consortium comprising Philips, Maschinenfabriek Breda, Rotterdamsche Droogdok, De Schelde, Stork, and Werkspoor.

Power and propulsion reactor studies.

Norway

Noratom AS

Cort Adelersgt. 16, Oslo.

Power reactor studies, consulting services, design and construction of complete plants, component manufacture and personnel training.

Consortium of 45 electrical, mechanical and shipbuilding firms. Main shareholders are Simonsen Radio A/S, Kongsberg Våpenfabrikk, A/S Norsk Elektrisk & Brown Boveri, A/S Hamar Jernstöperi & Mek. Verksted, A/S Nordisk Aluminiumindustri, Elektrokemisk A/S, Saugbrugsforeningen, Kværner Brug A/S, A/S Myrens Verksted, A/S Thunes Mek. Verksted, H. Th. Refsum, A/S Westad Armaturfabrik, A/S Per Kure, A/S Bergens Mek. Verksteder, Sig. Bergesen d.y. & Co., Raufoss Ammunisjonsfabrikker, Stavanger Electro-Staalverk A/S, Norsk Hydro, Standard Telefon og Kabelfabrikk, A/S Hafslund, Marinens Hovedverft, A/S Strömmens Verksted, De-No-Fa A/S, Christiania Bank og Kreditkasse, Storbrand Insurance Co. Ltd., Orkla Grube-Aktiebolag, Bergens Privatbank, Aktieselskapet Borregaard, Christiania Spigerverk, A/S Thor Dahl, Anders Johre, Shipowner.

Rederiatom AS

c/o Sigval Bergesen D.Y., PO 1351 (Vika), Oslo.

Propulsion reactor studies.

Consortium of shipowners.

Spain

Cenusa

Association of Hydroelectrica Espanola, Compania Sevillana de Electricidad, and Union Electrica Madrilena.

Created to purchase and operate nuclear power stations.

Nuclenor S.A.

Association of Iberduero, Electra de Viesgo, and other electricity companies.

Created to purchase and operate nuclear power stations.

Sweden

A. B. Atomenergi

PO Box 9042, Stockholm 9.

Research and development, reactor design and fuel fabrication. Operate four research reactors, a 30 MW test reactor, and construct a prototype heating and power reactor.

State controlled company in which the majority of Swedish industries participate, created for the implementation of the Swedish nuclear energy programme.

ASEA

Västerås.

Constructed the R2-0 and R3/Adam reactors design studies for R4-Eve.

Associated with Atomics International.

Atomkraftkonsortiet Krångede AB (AKK Atomic Power Group)

Stureplan 19, Stockholm.

Invited tenders for a 50 to 60 MW(e) reactor station to be erected on the Simpevarp Peninsula.

Formed by eight electricity companies for the purchase of nuclear power stations.

Nydquist & Holm AB (Nohab)

Trollhattan.

Reactor component manufacture.

Member of the Bofors Group of companies. Collaborates with AB Atomenergi and ASEA in the design of the R4-Eve reactor.

Switzerland

Reaktor AG

Bärengasse 29, Zürich.

Operate two research reactors at Wurenlingen. Develop heavy-water moderated and cooled reactors for heating and power production.

Consortium of Brown Boveri, Escher Wyss, Sulzer Brothers, and other Swiss industrial interests.

Suisatom AG

Bahnhofplatz 3, Zurich.

Promotion of nuclear energy development in Switzerland.

Consortium formed by four electricity companies and later joined by the Swiss Federal Railways. Associated with International General Electric and Reaktor AG.

'Engineering' Appointments Section

ROAN ANTELOPE COPPER MINES LIMITED
NORTHERN RHODESIA

ELECTRICAL ENGINEER

This is a senior appointment and entails full responsibility to the Company's Resident Engineer for all electrical engineering matters.

The Company's activities are extensive, consisting of the mining and milling of approximately 6 million tons of ore per year and a smelter production of approximately 90 thousand tons of copper per year. The company also operates certain ancillaries including two townships and two hospitals for European and African employees. Power consumption is over 220 million units per year, with a peak load of 34 thousand kw. and is supplied partly from the Company's own thermal generating station and partly from the Copperbelt 66 kv. grid system which is fed from the Kariba Hydro-Electric Scheme.

The initial basic salary although commensurate with qualifications and experience will be in excess of £2000 per annum. In addition to basic salary there is a cost-of-living allowance currently £6 10s. 0d. per month. There is also a variable bonus which, at the present time, is 39 per cent. of basic salary. The successful candidate will be required to join the Company's Pension and Life Assurance Scheme. Employees contribute 5 per cent. of basic earnings, and the Company contributes 5 per cent. for the first year increasing its contribution by ½ per cent. for each completed year of service. There is also a contributory Medical Benefit Scheme.

Leave at the rate of 55 days per annum may be accumulated over a period of 3 years. Passage fares to Northern Rhodesia will be paid for the employee and his family.

Accommodation in a large three bedroomed house is available on engagement at a sub-economic rental.

Applicants, who should have a degree or equivalent qualification in Electrical Engineering, be Corporate members of the Institute of Electrical Engineers, and also have had previous experience in heavy engineering and labour relations, should send particulars of age, qualifications and experience, in confidence, to:—

D. J. BEAKE,
Selection Trust Building,
Mason's Avenue, Coleman Street,
London, E.C.2.

B 959

PUBLIC APPOINTMENTS

CITY OF BIRMINGHAM
EDUCATION COMMITTEE
ASTON TECHNICAL COLLEGE
WHITEHEAD ROAD, BIRMINGHAM, 6

Principal: D. DUDGEON STOCKLEY, B.Sc., M.I.Mech.E.

Applications are invited for the post of ASSISTANT, GRADE B, in the Department of Mechanical Engineering, to teach MECHANICAL ENGINEERING (including production) subjects up to Ordinary and possibly Higher National Certificate level. An appropriate engineering qualification is essential, together with industrial and teaching experience.

Salary £700 × £27 10s. 0d. and final increment of £37 10s. 0d. to £1150. In fixing the commencing salary, increments are payable for industrial experience, and additions to the basic scale are payable in respect of approved courses of study and training and for a Degree or its equivalent.

Further particulars and an application form obtainable from the Principal, to whom applications should be returned within 14 days of the appearance of this advertisement.

E. L. RUSSELL,
CHIEF EDUCATION OFFICER. B 939

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

RESEARCH ASSISTANT required for an original investigation into the transient temperature distribution in the rotors of steam turbines. Applicants should have a physics, mathematics or engineering degree and should be interested in heat transfer and particularly in computational work in that field.

Salary: £750 p.a. with F.S.S.U. benefits.

Applications to DR. R. D. HOYLE, MECHANICAL ENGINEERING DEPARTMENT, CITY AND GUILDS COLLEGE, EXHIBITION ROAD, LONDON, S.W.7. B 982

BRISTOL COLLEGE OF SCIENCE AND TECHNOLOGY
(COLLEGE OF ADVANCED TECHNOLOGY)
DEPARTMENT OF MECHANICAL ENGINEERING

The Governors invite applications for the following three appointments at LECTURER grade. The Department works in close liaison with the Departments of Aeronautical and Electrical Engineering and the duties extend over Dip. Tech., Higher National Diploma and Higher National Certificate courses.

(*a*) LECTURER to be responsible for teaching Machine Drawing and Design. Knowledge of Production Processes, Jig and Tool Design, and willingness to assist on the drawing aspects of laboratory and project development desirable.

(*b*) LECTURER to teach Metallurgy. Ability to offer some related subject in Production Engineering desirable.

(*c*) LECTURER to teach mechanics of Machines. An interest in vibration studies desirable.

Salary: Burnham Technical Report, 1959:—
£1370 × £35 (4) and £40 to £1550.

Application forms and details from REGISTRAR, COLLEGE OF SCIENCE AND TECHNOLOGY, ASHLEY DOWN, BRISTOL, 7. B 933

UNIVERSITY OF NOTTINGHAM
RESEARCH FELLOWSHIP
IN PRODUCTION ENGINEERING

ENGINEERS, PHYSICISTS or MATHEMATICIANS interested in the study of Production Processes or the Application of Statistics to Production Problems are invited to apply for the above Fellowship. Value £750 per annum, plus membership of the Universities Superannuation Scheme. Industrial or research experience an advantage. Conditions of appointment and application form, to be returned by 31st MAY, from the REGISTRAR. B 930

DERBY AND DISTRICT COLLEGE OF TECHNOLOGY

Principal: T. HEAP, Ph.D., M.Sc., F.R.I.C., A.M.B.I.M.

Applications are invited for the following posts in the Mechanical Engineering Department, duties to commence 1st September, 1960.

1. SENIOR LECTURER to specialise in Strength of Materials and Modern Methods of Material Testing. Applicants should have a good honours degree, good industrial and teaching experience.
2. LECTURER to teach Theory of Machines, Applied Mechanics, Thermodynamics or Mechanics of Fluids to H.N.C., H.N.D. and London B.Sc. Standard. Applicants should have a University degree or equivalent and good industrial and teaching experience.
3. ASSISTANT, GRADE II (2 POSTS) to teach Workshop Technology, Workshop Science and Engineering Drawing. Applicants should have a Final Certificate in Machine Shop Engineering or equivalent.
4. ASSISTANT, GRADE A (2 POSTS) to teach Science, Drawing and Technique to students in Machine Shop Engineering, Sheet Metal Work, Steel Fabrication, Welding, Foundry and Patternmaking, or Motor Vehicle Mechanics courses. Applicants should have a City and Guilds Certificate in one of the trades subjects and be prepared to teach general subjects in other courses.

Salary will be in accordance with the Burnham Technical Scales:—

Senior Lecturer ...	£1550 by £50 to £1750.
Lecturer ...	£1370 by £35 to £1550.
Assistant, Grade B	£700 by £27 10s. to £1150.
Assistant, Grade A	£520 by £27 10s. to £1000.

Application forms and further particulars can be obtained from the PRINCIPAL, DERBY AND DISTRICT COLLEGE OF TECHNOLOGY, KEDLESTON ROAD, DERBY, by whom completed applications should be received not later than two weeks after the appearance of this advertisement. B 962

CIVIL ENGINEERS

MINISTRY OF TRANSPORT: CIVIL ENGINEERS. Pensionable posts for men and women at least 25 and under 35 on 1.1.60 (extension for regular Forces service, Overseas Civil Service, established civil service, and temporary Government service as Civil Engineer). Candidates must have achieved Corporate Membership of Institution of Civil Engineers or passed examinations necessary for attaining such membership. Experience in road and bridge construction essential; knowledge of Highways Authorities' procedure desirable. Starting salary (men, London) from £830 to £1125 according to age. Scale maximum (London) £1300. Promotion prospects.—Write CIVIL SERVICE COMMISSION, 17, NORTH AUDLEY STREET, LONDON, W.1, for application form, quoting S/64/8. B 966

TEMPERATURE EXPERIMENTAL OFFICER

MINISTRY OF POWER, H.Q., LONDON, require TEMP. EXPERIMENTAL OFFICER, preferably under 31. Duties:—abstracting scientific articles; preparation of surveys of current literature, briefs and memoranda on fuel and power subjects. Min. Quals. H.N.C. or Inter.B.Sc. or equiv. Some knowledge of terms used in fields of fuel and power, ability to translate French and German essential; knowledge of Russian an advantage. Salary: £1005-£1233 (men), £985-£1203 (women). Five-day week. Prospects of Establishment.—Forms from MINISTRY OF LABOUR, TECHNICAL AND SCIENTIFIC REGISTER (K), 26, KING STREET, LONDON, S.W.1, quoting A.196/OA. B 968

UNIVERSITY COLLEGE OF GHANA

Applications are invited for (A) SENIOR RESEARCH FELLOWSHIP and (B) RESEARCH FELLOWSHIP in the POST GRADUATE ENGINEERING RESEARCH UNIT. Prime duties will be to conduct research in soil mechanics. Salary scales (under review): (A) £G1700 by 75 to £G2150 p.a.; (B) £G1000 by 50 to 1350 by 75 to £G1800; £G1850 p.a. Entry point according to qualifications and experience. F.S.S.U. Outfit and family allowances. Passages for appointee and family on appointment, leave and normal termination. Part-furnished accommodation at a charge not exceeding 7.5 per cent. of salary.—Detailed applications (6 copies) naming three referees by 10th June, 1960, to SECRETARY, INTER-UNIVERSITY COUNCIL FOR HIGHER EDUCATION OVERSEAS, 29, WOBURN SQUARE, LONDON, W.C.1, from whom further particulars may be obtained. B 967

NEW ZEALAND
MINISTRY OF WORKS

The New Zealand Government Ministry of Works invites applications for Permanent Staff appointments. Positions available are:

CIVIL ENGINEERS
Qualifications—Corporate membership of the Institution of Civil Engineers, London. Commencing salaries from £955-£1525 p.a.

ASSISTANT CIVIL ENGINEERS
Qualifications—A University Degree in Civil Engineering which gives exemption from Final Parts I and II of the A.M.I.C.E. examination; or other qualifications exempting from Parts I and II of A.M.I.C.E. plus at least 5 years' appropriate experience. Commencing salaries from £870-£1060 p.a.

MECHANICAL AND ELECTRICAL ENGINEERS (AND ASSISTANTS)
Qualifications—Corporate membership of the Institutions of Mechanical or Electrical Engineers, London, or for Assistants a University Degree in Mechanical or Electrical Engineering or Graduate Membership of the above Institutions. Commencing salaries, depending on experience, for Engineers £955-£1525 and for Assistants up to £1060 p.a.

BUILDING SERVICES ENGINEERS (AND ASSISTANTS)
Qualifications—Corporate membership of the Institution of Mechanical Engineers or of the Institution of Heating and Ventilating Engineers, London, or for Assistants, a University degree in mechanical engineering or Graduate membership of the above Institutions. Commencing salaries, depending on experience, for Engineers £955-£1525 per annum and for Assistants up to £1060 p.a.

DRAUGHTSMEN—CIVIL AND STRUCTURAL
Qualifications—Ordinary or Higher National Certificates or the final examination of the City and Guilds, London, or Associate Membership of the Institution of Structural Engineers are desirable but primary requirement is for skilled and speedy draughtsmen with substantial experience at the drawing board and in the types of civil engineering work designed by the Ministry of Works. Commencing salary up to £1060 per annum.

DRAUGHTSMEN—MECHANICAL, ELECTRICAL AND BUILDING SERVICES
Qualifications—Ordinary or Higher National Certificate in Mechanical or Electrical Engineering or equivalent examination, and at least 3 years' experience in draughting, design and calculations. Commencing salaries up to £1060 per annum.

QUANTITY SURVEYORS AND ASSISTANT QUANTITY SURVEYORS
Qualifications—Quantity Surveyors must be Associates of the Royal Institute of Chartered Surveyors or the Quantity Surveyors' Institute. Assistant Quantity Surveyors should have passed the intermediate sections of those examinations.

For both positions experience is required in the measuring and pricing of the building and allied trades, in final accounts and adjustment of contracts.

Commencing salaries up to £1285 for Quantity Surveyors and up to £1060 for Assistants.

Enquiries, mentioning this publication, quoting reference number B11/30/22 and indicating the position sought, should be addressed to the High Commissioner for New Zealand, 415, Strand, London, W.C.2. Full details of housing available, fares payable, career prospects, type of work, terms of contract, local conditions and application forms will then be supplied. B 929

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

PATENTS EXPLOITATION

Applications are invited for a post in LONDON for PATENTS EXPLOITATION. The work will include:—

(*a*) The exploitation of some of the inventions made within the Authority and the appraisal of the market for such inventions.

(*b*) Consultation with Authority staff on their inventions.

Applicants should have an Honours degree in Science or Engineering or corporate membership of one of the senior professional institutions. A broad rather than a specialist knowledge is needed, together with the ability to appreciate the exploitation possibilities of patented and unpatented inventions arising from different fields of technology.

Previous success in a technical post will be looked for. Experience in an industrial Commercial or Technical Sales Department and fluency in a major European language would be a decided advantage. Age about 30. Salary £1370-£1825 a year according to qualifications and experience, plus £75 London Allowance. Contributory superannuation scheme.

Send postcard for application form quoting reference NUMBER 128 to

ESTABLISHMENTS OFFICER,
U.K. ATOMIC ENERGY AUTHORITY,
ROOM 327 (D.H.),
11, CHARLES II STREET, LONDON, S.W.1.

Closing date 24th MAY, 1960. B 972

COLLEGE OF ADVANCED TECHNOLOGY, BIRMINGHAM

Owing to the continued expansion of the College following its designation as a College of Advanced Technology, additional posts exist as follow:—

READERS in CIVIL ENGINEERING
MECHANICAL ENGINEERING
PRODUCTION ENGINEERING
(METROLOGY AND/OR MACHINE TOOLS)
HEAVY CURRENT ELECTRICAL ENGINEERING

Previous experience in research is essential and the successful candidates will be required to initiate research in their particular subjects and undertake a limited amount of lecturing on advanced topics.

Salary Scale: READERS (Men) £1800-£2100
(Women) £1440-£1680 (plus equal pay increment)

Further particulars and forms of application from—

The Bursar, College of Advanced Technology, Gosta Green, Birmingham, 4.

Applications to be received within 14 days of this advertisement. Please quote "K."

K. R. PILLING, Clerk to the Governors. B 931

BOROUGH POLYTECHNIC
BOROUGH ROAD, LONDON, S.E.1

Principal: JAMES E. GARSIDE, M.Sc.Tech., Ph.D., F.R.I.C., F.I.M., F.Inst.F.

The Governors invite applications for the following appointments:—

DEPARTMENT OF MECHANICAL ENGINEERING
Head of Department: G. L. H. Bird, B.Sc.(Eng.), M.I.Mech.E., M.Inst.R.

LECTURERS IN MACHANICAL AND IN PRODUCTION ENGINEERING

Applicants for each of the two posts should be University Graduates in Mechanical Engineering, with industrial, research and/or teaching experience. Courses involved include Sandwich Diploma Courses. Excellent opportunities and facilities for research.

For one post the Lecturer will be mainly concerned with Engineering Production subjects. A post-graduate or professional qualification in Production Engineering would be an added qualification.

For the other post, the Lecturer will be mainly engaged upon Engineering Thermodynamics and Heat Transfer.

SALARY (MEN).

Lecturers: Within the range £1408 to £1601 per annum.

The point of entry on the salary scale and the maximum depending on age, qualifications, training and experience.

Further particulars and Application Form, which should be returned as soon as possible, obtainable from the undersigned.

FREDK. J. PACKER,
CLERK TO THE GOVERNING BODY.
B 958

BOROUGH POLYTECHNIC
BOROUGH ROAD, LONDON, S.E.1

Principal: JAMES E. GARSIDE, M.Sc.Tech., Ph.D., F.R.I.C., F.I.M., F.Inst.F.

RESEARCH ASSISTANTS

Applications are invited from graduates or those about to graduate for RESEARCH ASSISTANTSHIPS in connection with the following investigations:—

The Mechanical Properties of Plastics.
Mechanical Seals in Rotating Shafts.

The research projects envisaged are appropriate for submission (by suitably qualified person) for a higher degree of the University of London.

Research Assistants are expected to undertake as part of their duties, a limited amount of teaching for which payment is made.

Total remuneration approximately £450-£500 p.a.

Further particulars and Application Form, which should be returned as soon as possible, obtainable from the undersigned.

FREDK. J. PACKER,
CLERK TO THE GOVERNING BODY.
B 957

ASSISTANT TEACHERS

THE COUNTY BOROUGH OF CROYDON EDUCATION COMMITTEE invite applications from suitably qualified persons for the following posts in the Mechanical Engineering Department which will become tenable from September, 1960:—

CROYDON TECHNICAL COLLEGE,
FAIRFIELD, CROYDON.
Principal: D. A. GREEN, M.B.E., B.Sc., M.Ed.

1. ASSISTANT GRADE "B" FOR THE POST OF FULL-TIME TEACHER OF MECHANICAL ENGINEERING.

Candidates should possess good academic qualifications and industrial experience.

The duties will include the teaching of Machine Shop Engineering to Final City and Guilds standard.

Salary:—Burnham Technical Scale for Assistants Grade "B" with London Area Allowance.

2. ASSISTANT GRADE "A" FOR THE POST OF FULL-TIME TEACHER OF MECHANICAL ENGINEERING.

The duties will include the teaching of Craft Science and Technology, together with workshop practice in one or more of the following subjects:—

Motor Vehicle work, Welding, Heating and Ventilating Operative Work, Machine Shop Engineering.

Salary:—Burnham Technical Scale for Assistants Grade "A" with London Area Allowance.

Further particulars and forms of application may be obtained from the CHIEF EDUCATION OFFICER, EDUCATION OFFICE, KATHARINE STREET, CROYDON, and should be returned to the Principal within twenty-one days of the appearance of this advertisement. B 949

THE MANCHESTER COLLEGE OF SCIENCE AND TECHNOLOGY
(FACULTY OF TECHNOLOGY IN THE UNIVERSITY OF MANCHESTER)

Applications are invited for a LECTURESHIP IN MATHEMATICS in the College with corresponding title and status in the University of Manchester.

Applicants must be graduates and either mathematicians with experience of engineering or engineers with mathematical ability. The person appointed will be expected to lecture to students taking degrees in mathematics or to students in other departments of the Faculty and to take an active part in the research work of the department.

Salary according to experience in the range £900 by £50 to £1350 by £75 to £1650 with F.S.S.U. and children's allowances.

Further particulars anf forms of application may be obtained from the REGISTRAR, THE MANCHESTER COLLEGE OF SCIENCE AND TECHNOLOGY, MANCHESTER, 1, to whom completed forms should be returned by SATURDAY, 14th MAY, 1960. B 952

UNIVERSITY OF BRISTOL

Applications are invited from Honours graduates in Engineering of any nationality for the WERTHEIMER TRUST POSTGRADUATE SCHOLARSHIP in CIVIL, MECHANICAL, ELECTRICAL or AERONAUTICAL ENGINEERING, which will be awarded by the Society of Merchant Venturers of Bristol on the recommendation of the University.

The Scholarship is of a value between £400-£600 per annum (according to qualifications and experience) plus payment of fees; is awarded initially for one year and is renewable. The successful candidate will be expected to undertake a limited amount of demonstrating. Candidates should be at least 25 and have served two postgraduate professional years in industry.

Applications (3 copies) by letter, stating age, qualifications, experience, current academic activities, outline of proposed research, and names of two referees, must be received not later than 1st JUNE, 1960, by the REGISTRAR, THE UNIVERSITY, BRISTOL, 8. B 946

UNIVERSITY OF AUCKLAND
NEW ZEALAND
LECTURESHIP IN CIVIL ENGINEERING

Applications are invited for the above-mentioned appointment.

The salary scale is £1250-£1700 per annum and an allowance is made towards travelling and removal expenses.

Further particulars and information as to the method of application must be obtained from the SECRETARY, ASSOCIATION OF UNIVERSITIES OF THE BRITISH COMMONWEALTH, 36, GORDON SQUARE, LONDON, W.C.1.

Applications close, in New Zealand and London, on 15th JUNE, 1960. B 973

SURREY EDUCATION COMMITTEE
KINGSTON TECHNICAL COLLEGE,
FASSETT ROAD,
KINGSTON-UPON-THAMES

Applications are invited for the following posts from September, 1960:—

DEPARTMENT OF MANAGEMENT, WORK STUDY AND PRODUCTION

Three Assistants Grade B in Production Engineering. The persons appointed will be mainly responsible for the teaching of Workshop Practice and Technology, but will also be required to assist with the teaching of allied subjects in one of the following: Automobile Engineering Practice; Oxy-acetylene and electric arc welding; Mercantile Marine Engineering Practice; Electronic Engineering Practice.

Salary Scale in accordance with the Burnham Technical Report, 1959:—£700 by £27 10s. (£37 10s.) to £1150 p.a. plus London Allowance.

Further particulars for each post and form of application from the Principal, on receipt of stamped addressed envelope. B 970

SPECIALIST IN MATHEMATICS AND ENGINEERING DRAWING

UNESCO requires a SPECIALIST in MATHEMATICS and ENGINEERING DRAWING for the POLYTECHNIC INSTITUTE (JUNIOR COLLEGE) in TEHERAN, PERSIA. Duties: Teaching and organisation of courses. Qualifications: Engineering degree, and teaching experience in mathematics related to workshop and design problems, plus industrial experience. Working knowledge of French essential. Duration: 1-2 years initially. Salary: £2600 and generous allowances. All emoluments tax free. For Job Description and application forms, write to MINISTRY OF LABOUR (E.9), ALMACK HOUSE, 26-28, KING STREET, LONDON, S.W.1. B 969

MANCHESTER CORPORATION WATERWORKS UNDERTAKING

JUNIOR ASSISTANT ENGINEER (ELECTRICAL) required. Salary APT I (£610/765) according to qualifications and experience. Age 22/26.

Applicants should have served a recognised engineering apprenticeship, with subsequent D.O. experience, and preferably have H.N.C. or equivalent qualifications.

The position offers interesting all-round experience in the maintenance of installations (domestic, pumping stations, control schemes, etc.) situated in Manchester, at headworks, and on aqueducts; also in the design, construction and commissioning of electrical installations for large plants to be constructed.

Applications, stating age, education, training, qualifications and experience to be sent to the ENGINEER AND MANAGER, WATERWORKS DEPARTMENT, TOWN HALL, MANCHESTER 2, by the 16th MAY, 1960. B 886

UNIVERSITY OF LONDON KING'S COLLEGE
TUTORIAL STUDENTSHIP IN MECHANICAL ENGINEERING

A TUTORIAL STUDENTSHIP is offered in the Department of Mechanical Engineering. The value is £425 a year, with free tuition, from 1st October, 1960. Applicants must be graduates or about to graduate and will be required to read for a higher degree and to give a limited amount of assistance by demonstrating.

The successful applicant will be expected to take part, under supervision, in research in Refrigeration.

Particulars and forms from the REGISTRAR, KING'S COLLEGE, STRAND, W.C.2, whom completed applications should reach not later than MAY20. B 893

UNIVERSITY OF LONDON KING'S COLLEGE

SHELL STUDENTSHIPS IN CHEMICAL ENGINEERING

Value £375 each plus tuition fees. May be held for the one-year postgraduate course for the College Diploma in Chemical Engineering, or for the first year (with possible renewal) of higher degree work.

Applications are invited from graduates in Chemistry or Engineering. Forms must be obtained from the REGISTRAR, KING'S COLLEGE, STRAND, LONDON, W.C.2, and must reach him completed by MAY 26th, 1960. B 869

ADMIRALTY

NAVY WORKS DEPARTMENT

ARCHITECTURAL AND CIVIL ENGINEERING ASSISTANTS

Vacancies exist in Navy Works Department Drawing Offices for Architectural and Civil Engineering Assistants as shown. Posts are non-pensionable. Opportunities for transfer to Established staff will occur.

ENGINEERING ASSISTANTS.

Vacancies exist at Pinner (Middlesex), Portsmouth, Devonport, Liverpool, Chatham, Rosyth, Greenock, Macrihanish and Glen Douglas, and occur at Establishments elsewhere in the United Kingdom from time to time.

Applicants must be competent Draughtsmen and experienced designers in one or more of the following types of civil engineering works:—Structural steelwork; reinforced concrete; dock and harbour works; airfield construction; oil fuel schemes; roads, rail services and water supplies. O.N.C. or equivalent qualification. For the posts at Macrihanish and Glen Douglas preference will be given to candidates with surveying and setting out experience.

ARCHITECTURAL ASSISTANTS.

Vacancies exist at Pinner (Middlesex), and Portsmouth. Applicants must be competent Draughtsmen and will be required for work with Professional Architects on the preparation of designs for a wide range of new works, including new housing designs and estate layouts; all forms of accommodation; specialised technical buildings and industrial buildings in H.M. Dockyards. Preference given to candidates studying for professional qualifications.

SALARY: (National Rate—subject to slight variation dependent on location): starting from £550 p.a. (at age 21) to £760 p.a. (28 and over): maximum of scale—£875 p.a. Opportunities occur for promotion to Leading grade—salary maximum £1025 p.a. National Rate.

Five-day week; Annual Leave 18 days rising to 22 after 10 years.

Consideration will be given to successful candidates being granted assistance to obtain professional or technical qualifications.

Candidates, who must be British subjects, are invited to apply, in writing, (giving details of experience) to DIRECTOR GENERAL, NAVY WORKS, ADMIRALTY, CHAMBERLAIN WAY, PINNER, MIDDLESEX.

Interview will be arranged locally. B 915

CITY OF OXFORD EDUCATION COMMITTEE

COLLEGE OF TECHNOLOGY

Applications are invited for the following posts from 1st September, 1960:—

LECTURER IN MECHANICAL ENGINEERING to teach Mechanical Engineering subjects up to H.N.C. and H.N.D. Applicants should possess either a university degree in Engineering or Corporate Membership of the Institution of Mechanical Engineers, and have good industrial experience. Some teaching experience would be an added recommendation.

Salary:—Burnham Technical Scale for Lecturers, viz., (Men) £1370 by £35 to £1550 per annum. Increments above the minimum of the scale may be allowed for approved industrial experienc.

Forms of application and further particulars may be obtained on receipt of a stamped addressed envelope, from the PRINCIPAL, COLLEGE OF TECHNOLOGY, HEADINGTON ROAD, OXFORD, to whom completed forms should be returned by MAY 18th, 1960. B 990

ASSISTANT MECHANICAL ENGINEER

A vacancy exists for the above post which is located in Birmingham.

The person appointed will be required to assist the Mechanical Engineer in the maintenance work on gas works plant and the installation of new plant. Candidates should have served an apprenticeship in engineering and have had further experience in general engineering and steam plant. Some knowledge of mechanical handling and of incentive schemes based on Work Study as applied to maintenance work will be an advantage. Possession of an Engineering Degree, Corporate Membership of the Institution of Mechanical Engineers, a Higher National Certificate in Mechanical Engineering or equivalent qualification is essential.

The salary for the appointment, which is pensionable and subject to medical examination, will be within the range of £1006-£1131 per annum.

Applications, stating age, training, qualifications and experience, together with the names of two referees, should be addressed to MR. J. E. WAKEFORD, DIVISIONAL GENERAL MANAGER, WEST MIDLANDS GAS BOARD, EDMUND STREET, BIRMINGHAM, 3, TO REACH HIM NOT LATER THAN THE 16th MAY, 1960. B 991

'ENGLISH ELECTRIC'

offers opportunities to

MECHANICAL, CHEMICAL & ELECTRICAL ENGINEERS & PHYSICISTS

These opportunities exist at all levels of seniority and we will be especially pleased to hear from men who have been successful in their initial design and development work and who feel that either their progress is restricted in their present position or they would welcome an opportunity of widening their experience in a new field. If your are interested in investigating these opportunities that we may be able to offer you why not write to the address below giving details of your previous experience, age, qualifications and salary. Correspondence will be treated in strictest confidence.

A few of the vacancies are indicated below but many others exist and the Company is always prepared to accommodate promising men in their organisation. We welcome enquiries.

ELECTRICAL & MECHANICAL ENGINEERS

For development investigations on reactor equipment with special reference to control gear and fuelling and fuel handling systems, with associated electrical and data processing equipment. These investigations would involve handling large items of plant operating at high temperatures and pressure.

These appointments are for men of degree calibre with post graduate experience preferably on development work, although applications from ex-apprentices with H.N.C. would be considered.

ENGINEERS, PHYSICISTS & MATHEMATICIANS

To be responsible for the examination of problems connected with nuclear reactor fuel element design and development, and for the design of new fuel elements.

A good honours degree in the appropriate subject is essential and the experience required may be classified as follows:

1. Interest in the creep deflection of structures at high temperature, preferably with a background of the mechanics of plastic solids, or of the plastic theory of structures.
2. Experience in stress analysis with a good mathematical background.
3. Experience in the engineering applications of physics.

GAS CIRCUIT ENGINEERS

To conceive the design of gas circuits and study the economic selection of components circulator drive systems and method of gas flow. The duties could also cover analysis of local performance specification of engineering features and the behaviour of the system under fault conditions apart from general thermodynamic and aerodynamic problems.

These positions require men of honours degree calibre, and experience in turbine or axial compression, thermodynamics and aerodynamics would be an advantage.

DESIGN ENGINEERS

Mechanical, civil or chemical engineers who are interested in design problems associated with pressure vessels and structures, heat transfer and fluid mechanics (as applied to the cooling of large vessels), vibrations, bearing friction or the determination of temperature distribution in plant, would find interest in this sphere.

The nature of these problems would require men with honours degree (or its equivalent) and the ability to think clearly.

DESIGNERS

To be responsible for the design of apparatus for investigating problems of heat transfer, air flow and the performance of mechanical components of reactors.

A degree or H.N.C. together with workshop experience and two to three years' design experience in the field of medium mechanical engineering is essential. A knowledge of pressure vessels and pipework could be an advantage but the main requirement is for a man with flexibility and originality of approach who is prepared to follow a design through to its installation and commissioning in a laboratory.

ELECTRICAL ENGINEERS

Interested in design and contract engineering especially in connection with reactor auxiliary plant and control systems and reactor automatic control systems. The work involves responsibility for schemes from design initiation to site completion and a small amount of travelling may be involved in connection with technical liaison with outside sub-contractors and other works of the Company.

Experience is necessary in one or more of the following fields: relay and contactor control systems, safety interlocking systems, telecommunication circuiting, automatic control system analysis and servo systems and components.

It is expected that the successful applicant will hold a degree or H.N.C. but capability and achievement are the primary considerations.

MECHANICAL & CHEMICAL ENGINEERS & PHYSICISTS

To perform theoretical and experimental investigations associated with problems of heat transfer and gas flow in nuclear reactors. These positions require a degree in chemical or mechanical engineering and experience or interest in heat transfer or aerodynamic research and development work.

There are also positions available for O.N.C. or H.N.C. men with similar interests or experience in the commissioning or performance testing of power station or chemical plant.

Please address correspondence and enquiries to the

Technical Staff Officer, C.P.S., Marconi House, Strand, W.C.2

quoting reference EG 1816G B 932

SENIOR DRAUGHTSMAN

required

for design of plant and layout for manufacture of investment-moulded steel castings. Should hold H.N.C. and have had experience in connection preferably with this type of process, or in steel foundry or other metallurgical plant, or chemical plant. Applications, giving appropriate details of experience, should be sent to the

Personnel Officer,
Fairey Aviation Limited,
Hayes, Middlesex. B904

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m and i DRAUGHTSMAN

(Plant and Factory Layout)

Applications are invited for a new vacancy in the Works Engineers Department concerned with a wide range of plant and factory layout and services.

Good experience in this field is necessary together with a minimum technical qualification of O.N.C. or equivalent.

The Company is expanding its activities and plant and this post offers good opportunities together with a good commencing salary and conditions of service.

Applications giving details of age, qualifications, experience and current salary should be sent to:—

The Personnel Manager,

THE MICANITE & INSULATORS CO. LTD.,

Empire Works, Blackhorse Lane, Walthamstow, London, E.17. B 963

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

CULHAM LABORATORY

Near Abingdon, Berks.

Two posts exist at the new Laboratory now being set up by the U.K.A.E.A. to carry out research into controlled thermonuclear reactions and plasma physics.

POST 1: ELECTRICAL FOREMAN
To supervise manufacture of electrical equipment for the first major experiment and be responsible for installation and maintenance of the equipment.

POST 2: MECHANICAL FOREMAN
To supervise manufacture, installation, and operation of experimental plant and equipment for the first major experiment.

QUALIFICATIONS: (i) Recognised engineering apprenticeship or equivalent training.
(ii) Supervisory experience.
O.N.C. or equivalent is desirable.

In addition:
For POST 1—experience in the high voltage field necessary and electronics knowledge useful.
For POST 2—experience of all types of machinery and fitting to very fine limits.

SALARY: £925 (at age 30 or over)-£1105 p.a.
Housing and contributory pension schemes.

Send POSTCARD for details to the—

SENIOR RECRUITMENT OFFICER (1663/26),
A.E.R.E.,
HARWELL,
DIDCOT, BERKS. B 987

CITY OF SHEFFIELD EDUCATION COMMITTEE COLLEGE OF TECHNOLOGY

DEPARTMENT OF ENGINEERING

SANDWICH COURSE IN THE ENGINEERING OF PRODUCTION

DEPARTMENT OF SCIENCE

SANDWICH COURSE IN METALLURGY

THREE-YEAR SANDWICH COURSES leading to Higher National Diplomas in The Engineering of Production and in Metallurgy are in operation. In each year of the Course, students will spend six months full-time in College and six months in Industry. For entry to the Courses, the required qualification will be either a good Ordinary National Certificate or appropriate passes at Ordinary and Advanced levels in the General Certificate of Education.

Full particulars may be obtained from the Registrar, College of Technology, Pond Street, Sheffield, 1, to whom early application for admission to the Courses in September 1960, should be made.

T. H. TUNN,
DIRECTOR OF EDUCATION.

EDUCATION OFFICE,
SHEFFIELD, 1. B 928

RAILWAY ELECTRIFICATION

The Railway Modernisation Programme, increasing in activity, offers excellent opportunities to men qualified and experienced in Structural and Civil Engineering.
BRITISH INSULATED CALLENDER'S CONSTRUCTION CO., LTD., have immediate vacancies for the following positions:—

DESIGNERS

Ref. "A" First Class Designers capable of working with the minimum of supervision.

Experienced in the design of light steel framed portal structures and associated foundations.

Ref. "B" Structural or Civil Engineering Designers experienced in general structural engineering and/or foundation design.

Conditions of employment are excellent including Bonus and superannuation schemes.

These vacancies are at Kirkby near Liverpool where interviews for selection will take place. Please submit application in writing, stating age, education and previous experience to:—

THE PERSONNEL OFFICER,
BRITISH INSULATED CALLENDER'S CABLES, LTD.,
PRESCOT, LANCS.

A member of the BICC Group of Companies.

B 961

UNIVERSITY OF CAMBRIDGE DEPARTMENT OF CHEMICAL ENGINEERING

There is a vacancy for a

UNIVERSITY LECTURER or DEMONSTRATOR

with qualifications in chemical or mechanical engineering, physical chemistry or physics

Application forms and further information from the Secretary of the Appointments Committee, Department of Chemical Engineering, Pembroke Street, Cambridge

Closing date 1 June, 1960 B 955

LECTURESHIP IN ENGINEERING

UNIVERSITY COLLEGE OF SWANSEA

A vacancy exists for an ASSISTANT LECTURER or LECTURER in the Department of Engineering at Swansea. Applicants should preferably have interests in the general field of Strength of Materials, but those with interests in any branch of either Civil or Mechanical Engineering will be considered.

ASSISTANT LECTURER:
Applicants should hold a good Honours degree and have at least one year's industrial or post-graduate experience. Research work is strongly encouraged and the assistant may register for a Ph.D. degree.

LECTURER:
Applicants should hold a good Honours degree and have not less than three year's post-graduate research or industrial design experience. It is hoped to appoint a man who will be active in some field of research of his own choice, although if he so wishes, he may join an existing project.

A revision of salary scales is now under discussion. The present scales are:
Assistant Lecturer £700-£850 p.a.
Lecturer ... ... £900-£1650 p.a.
and the initial salary can be at any point within these ranges. F.S.S.U. benefits and family allowances.

Further particulars can be obtained from the REGISTRAR, UNIVERSITY COLLEGE, SINGLETON PARK, SWANSEA, with whom applications six copies) should be lodged before MAY 24, 1960. B 989

MIDDLESEX COUNTY COUNCIL

EDUCATION COMMITTEE

ENFIELD TECHNICAL COLLEGE

QUEENSWAY, ENFIELD

Required from September, 1960:
LECTURER IN CIVIL ENGINEERING to teach Civil Engineering subjects up to Diploma standard. Candidates must be University Graduates in Civil Engineering and at least Graduate Members of the Institution of Civil Engineers. They should have had industrial and/or teaching experience.

Salary within the range: £1408-£1601 per annum.

Application forms (foolscap s.a.e.) from the Principal, to whom completed forms should be returned within 14 days of the appearance of this advertisement.

C. E. GURR, M.Sc., Ph.D.,
SECRETARY TO THE EDUCATION COMMITTEE. B 984

DRAUGHTSMEN

The following vacancies have occurred at Etruria Gas Works, Stoke-on-Trent:
1 post within the range of £733-£813 per annum.
1 post within the range of £629-£709 per annum.

Candidates for the first post should hold an appropriate Higher National Certificate and have considerable experience in an engineering drawing office, whilst candidates for the second should possess an appropriate Ordinary National Certificate and have completed a drawing office apprenticeship or have equivalent experience.

The posts are pensionable and the persons appointed may be required to pass a medical examination.

Applications, stating age, qualifications, experience, and the post required, should be addressed to MR. L. W. JOHNSON, DIVISIONAL GENERAL MANAGER, WEST MIDLANDS GAS BOARD, ETRURIA GAS WORKS, STOKE-ON-TRENT, STAFFS, TO REACH HIM NOT LATER THAN THE 16th MAY, 1960. B 992

PAISLEY TECHNICAL COLLEGE

(CENTRAL INSTITUTION)

MECHANICAL ENGINEERING DEPARTMENT

Applications are invited for the following posts:
(*a*) SENIOR LECTURER IN MECHANICAL ENGINEERING.
(*b*) LECTURER IN MECHANICAL ENGINEERING.
(*c*) LECTURER IN PRODUCTION ENGINEERING.

Salary, according to experience, on the scales (*a*) £1560 to £1800, (*b*) £900 to £1550, (*c*) £900 to £1550 or £800 to £1270 depending on qualifications. Appointees to posts (*a*) and (*b*) will be required to teach at honours degree level. For post (*c*) candidates offering Industrial Administration will be given preference.

Applications, stating age, qualifications and experience together with the names of referees, should be addressed to the undersigned, from whom further information may be obtained.

H. N. HENRY,
PRINCIPAL.
PAISLEY TECHNICAL COLLEGE,
GEORGE STREET, PAISLEY. B 993

CITY OF NOTTINGHAM

WATER DEPARTMENT

APPOINTMENT OF TWO

CIVIL ENGINEERING ASSISTANTS

Applications for the above permanent, pensionable appointments are invited from Engineering Graduates and/or Corporate Members of the Institution of Civil Engineers with five years' engineering experience which need not necessarily have been with a Water Undertaking. The Department has in hand a large programme of new works, offering considerable opportunities for gaining valuable experience. Salary, dependent upon qualifications and experience, in Grade A.P.T. IV, viz., £1065 by £55 to £50's (2) to £1220.

Applications, with names of two persons to whom reference may be made, to ENGINEER AND GENERAL MANAGER, WATER DEPARTMENT, CASTLE BOULEVARD, NOTTINGHAM, not later than the 23rd MAY, 1960.

T. J. OWEN,
TOWN CLERK.
THE GUILDHALL,
NOTTINGHAM. B 983

PORT OF MANCHESTER

ASSISTANT TO

MECHANICAL ENGINEER

THE MANCHESTER SHIP CANAL COMPANY have a vacancy for an ASSISTANT TO THE MECHANICAL ENGINEER. Applications for the position, which will carry good prospects of promotion, are invited from candidates who should not be more than 35 years of age, preferably holding a university degree in mechanical engineering or other suitable qualification and with practical experience in a position of responsibility. The salary offered will be in accordance with qualifications and experience. The successful candidate will be required to pass a medical examination and to become a member of the Company's contributory superannuation scheme.

Applications containing full particulars of age, education, qualifications and experience, should be addressed to the MECHANICAL ENGINEER, MANCHESTER SHIP CANAL COMPANY, SHIP CANAL HOUSE, KING STREET, MANCHESTER, 2, not later than 31st MAY, 1960. Envelopes should be marked "A.M.E. PERSONAL." B 940

APPOINTMENTS OPEN

GRADUATES

BP invites applications from GRADUATES, aged 23-26 years, with an honours degree in Petroleum Engineering, Engineering or Physics for employment as Assistant Production Engineers in Trinidad in the first instance. Duties will consist of assisting in all aspects of field production work, including well control, artificial lift, gas control, oil collection and well servicing. National Service obligations must have been fulfilled. Write, stating age and full details of qualifications and experience, quoting F.5744, to BOX 3250, c/o 191, GRESHAM HOUSE, E.C.2. B 994

SITE ENGINEER

SITE ENGINEER required by well known firm manufacturing a wide range of Mining, Roadmaking and Quarry Plant. Must be capable of directing all aspects of plant erection and controlling labour.—Full details of experience, age, salary required and when available, to BOX B 954, Offices of ENGINEERING.

PATENTS ASSISTANT

British subject with knowledge of engineering terms and wide interest in Engineering required for work in connection with patent applications, including editing translations of engineering patent specifications. O.N.C. or H.N.C. in Engineering an advantage. Education at least to G.C.E. standard in English and Mathematics.—Apply in own handwriting with details of age, education, subsequent career and salary sought, to BOX 204, REYNELLS, 44 CHANCERY LANE, W.C.2. B 845

THE BRITISH STEEL CASTINGS

RESEARCH ASSOCIATION

EAST BANK ROAD, SHEFFIELD, 2

requires a versatile qualified MECHANICAL ENGINEER (graduate or A.M.I.Mech.E.) as a Senior Investigator in the Plant Engineering Section. Progressive salary in range £750-£1500 p.a. depending on age, qualifications and experience. Superannuation scheme. Three weeks annual leave. Duties will comprise applied research and development relating to plant and equipment used in steel foundries both at the Association's headquarters in Sheffield and in the works of member companies. Applications which would be especially welcome from candidates with industrial and research and development experience should be made to the DIRECTOR. B 950

CIVIL ENGINEERS (JUNIOR)

CIVIL ENGINEERS (JUNIOR) required for temporary employment of approximately fifteen months on pre contract surveys for large project in Sierra Leone which includes road, railway, marine, plant and building construction. Successful applicants will be considered for transfer to Resident Engineer's Staff when established. Salary £1500 per annum plus 5 per cent. bonus; for married men separation allowance of £10 per month and £5 per month for each child. Return passage paid, free furnished quarters and medical attention. Life Assurance and Dependants Income Schemes. Write giving full details experience stating age, married or single to SIERRA LEONE DEVELOPMENT CO., LTD., DEPT. C.E.7, CITY GATE HOUSE, FINSBURY SQUARE, LONDON, E.C.2. B 943

CIVIL ENGINEERS

Merz and McLellan require Senior and Junior Civil Engineers for design work at Newcastle-upon-Tyne. The appointments are permanent pensionable positions and are concerned with a variety of very heavy Civil Engineering construction works. Applications by letter in the first instance bearing reference SAR should be sent to MERZ & McLELLAN, CARLIOL HOUSE, NEWCASTLE-UPON-TYNE, 1 B 953

INSTRUMENT TECHNICIAN

GLASSHOUSE CROPS RESEARCH INSTITUTE requires INSTRUMENT TECHNICIAN for development, adaptation and maintenance of instruments used by research departments. Appointment in Experimental Officer grade (£954-£1200), entry point depending on experience and ability; superannuation. Qualifications: H.N.C. or equivalent. Further particulars obtainable from SECRETARY to the INSTITUTE, WORTHING ROAD, LITTLEHAMPTON, SUSSEX, to whom applications, together with names of two referees, should be addressed before 24th MAY. B 958

PRODUCTION CONTROLLER

THE WELDLESS STEEL TUBE COMPANY

—specialists in hot steel working—have asked us to assist them in finding an experienced administrator to become Production Controller at their factory near Wolverhampton. He will be responsible to the Managing Director for planning production—though not for the actual production itself. His department exercises planning control from raw material through to finished product, including the examination of production methods and improving the utilisation of plant, materials and services.

This post will be attractive to men of a good degree standard, preferably with a professional engineering qualification, aged 30-40, with managerial background, knowledge of modern production control techniques and responsible experience in planning, progressing and statistical control.

Starting salary may be on either side of £1750 and there are excellent prospects for a man with drive and administrative common sense.

Write briefly in strictest confidence.

The Managing Director (RW.62), EXECUTIVE APPOINTMENTS LIMITED,
78 Wigmore Street, London, W.1.
B 935

PETROLEUM ENGINEERS

BP requires PETROLEUM ENGINEERS for overseas service in its Exploration Department. Applicants, aged between 21-27, must possess an Honours Degree in Physics, Mechanical Engineering or Petroleum Engineering. Previous oilfield experience would be an advantage. National Service obligations must have been fulfilled. Write, stating age and full details of qualifications and experience, quoting F.579, to BOX 3255, c/o 191, GRESHAM HOUSE, E.C.2. B 995

THE BRITISH SHIPBUILDING RESEARCH ASSOCIATION

has vacancies in the following two Grades in its Marine Engineering Section:—

(*a*) GRADE B.—This Grade includes persons who have been assessed as having the ability to initiate, lead and execute research. Qualifications required are a good University Degree in marine or mechanical engineering and with practical training and experience. Research experience and/or service at sea an advantage. The salary will be within the range of £800-£1600 per annum.

(*b*) GRADE C.—The Staff in this Grade are concerned with the conduct of the experimental side of investigations. Qualifications required are a Degree in marine or mechanical engineering, Higher National Certificate or equivalent qualification. Apprenticeship or practical experience in engineering. Research and/or sea going experience an advantage. The salary will be within the range of £725-£1350 per annum.

The commencing salary for each appointment will however depend upon age and qualifications. All appointments are subject to the Federated Superannuation System for Universities.

Applications with full particulars should be addressed to B.S.R.A., 5, CHESTERFIELD GARDENS, CURZON STREET, LONDON, W.1. B 951

THE MOTHERWELL BRIDGE & ENGINEERING COMPANY LTD.

DESIGN ENGINEERS

ASSISTANT CHIEF DESIGNER (REF. DD-1)

Applications are invited for the above post from honours graduates in Mechanical Engineering who have had several years' experience in the design of pressure Vessels, Chemical Plant and refinery equipment, and, in addition, design experience in structural steelwork.

Applicants should be between 30 and 35 years of age and be a Corporate Member of the Institute of Mechanical or Structural Engineers.

Duties will include the execution and responsibility for checking of designs. Applicants should have a good bearing and pleasant manner and be willing to travel as the scope of the position will extend to meeting representatives of other companies on technical matters.

An attractive commencing salary is offered and will be based upon the qualifications and experience of the successful applicant.

DESIGN ENGINEER (REF. DD-2)

Applications are invited from Engineers holding a degree or equivalent qualification in Mechanical or Structural Engineering for specialised design work on Gas, Chemical and Oil Refinery Plant and Equipment.

Applications from Engineers graduating this year will be considered.

The position carries responsibility for the execution of original designs and offers a wide scope for engineers wishing to specialise in this type of equipment. Commencing salary will be not less than £800 p.a. but would be increased above this depending on age and experience.

Both posts are pensionable and the company offer excellent Canteen and recreational facilities. Apply quoting reference number and giving full details of qualifications and experience to THE MOTHERWELL BRIDGE & ENGINEERING CO., LTD., P.O. BOX 4, MOTHERWELL. B 894

WORKS CONTROLLER

One of Britain's leading domestic appliance manufacturers requires Works Controller to organise planning and production of combination washing machine and spindryers and similar appliances. Applicants must have extensive knowledge and experience of the washing machine or domestic appliance industry.

Salary, £2500 p.a. plus excellent bonus.

Apply BOX B 986, Offices of ENGINEERING.

DESIGNER DRAUGHTSMEN

DESIGNER/DRAUGHTSMEN required for hydraulic and pneumatic valves. H.N.C. standard. Isleworth area. Applications with full details and salary required.—BOX B 945, offices of ENGINEERING.

THE DISTILLERS COMPANY LIMITED

MECHANICAL ENGINEERS

British Resin Products Limited, a subsidiary of the Distillers Company Limited, has vacancies for Mechanical Engineers in the Technical Service Department dealing with Polyethylene at its Barry, South Wales, plastics factory.

Candidates should hold a degree in Engineering or an equivalent qualification, and be aged between 27 and 35 years. They should have experience in the design and operation of injection moulding and extruding machines, be acquainted with drawing office practice and be able to discuss problems direct with customers.

Duties will include responsibility for equipment in the technical service laboratory, for design of modifications to equipment, and for advice to customers on mould and die design and on machine modifications for handling specific materials.

Write:
STAFF MANAGER,
THE DISTILLERS COMPANY LIMITED
21-22, BOLTON STREET
LONDON, W.1.

Quote ref. 24/60.E. B 927

M.T.D. (MANGULA) LIMITED

require an

ASSISTANT MECHANICAL ENGINEER

for their Copper Mines at Mangula, Southern Rhodesia. The successful candidate will be aged 35 or under, will have served a recognised apprenticeship in Mechanical Engineering and subsequently will have had at least three years' practical experience. He will be a Chartered Mechanical Engineer or possess the Higher National Certificate (Mechanical). Mining experience will be an advantage.

Salary £1680/1800 p.a. plus C.O.L.A. plus passage and expenses plus house at nominal rental, etc.

Application form and further particulars from—

MERZ AND McLELLAN,
MILBURN, ESHER, SURREY.
B 937

START-UP ENGINEERS

Qualified Engineers with experience in the processing industry and with aptitude and some experience of operations of chemical, refinery or allied type plants. Will be responsible to the Chief Start-Up Engineer and be in charge of site operations from pressure test to final acceptance. Must be able to deal with personnel at all levels from labour staff to client representative and to prepare reports and undertake special tests as required, for equipment evaluation. Must be free to travel abroad and be away from home for extended periods.

START-UP TECHNICIANS

Minimum G.C.E. standard with 2 to 5 years' experience in an engineering/construction firm and be conversant with engineering terminology and materials of construction. Technical or craft apprenticeship would be an advantage. Will work as shift operators in a start-up crew in support of the Senior Start-Up Engineer. Must be free to travel abroad and be away from home for extended periods.

Apply in writing to:—
Personnel Manager,
AIR PRODUCTS (G.B.) LTD.
49/50, Poland Street,
London, W.1. B 971

EUROPEAN REPRESENTATIVE

required
for

W.E. SYKES LIMITED

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To act as liaison between the respective Engineering Departments in America and England.
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To assist in building up appropriate contacts between the respective Engineering, Purchase, Production and Service Divisions.

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FORD of DAGENHAM
require
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Age 24-40

Experience of machine tool or special purpose machinery essential. H.N.C. standard with good knowledge of pneumatics and hydraulics an advantage.

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MR. G. McGUIRE,
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Companies

Fast Expansion in Electronic Control

Following up the 30 per cent expansion in their trading activities last year over the 1958 level, ELCONTROL, the Hertfordshire electronic control engineers, have taken three important steps for even better growth in the future.

Substantially larger machine shop facilities at the Hitchin, Hertfordshire, works have been obtained by a new factory extension.

The design, production and application development sections have been formed into a special products division for dealing with individual requirements. The company states that this step has been taken because of the growing demand from industry for purpose-built control schemes of considerable variety.

The new division is in addition to those handling the five main types of equipment produced by Elcontrol. They are: level control, photo-electric control, process timers and programmers, flame failure and burner control, and automatic weight control.

Additional appointments have been made to the staff of the technical department for a new programme of product development now being devised.

A Reflection of All Engineering

The HOFFMANN MANUFACTURING Company, a member of the BROWN BAYLEY group, is as Mr. J. W. Garton, the chairman of Brown Bayley says in the annual report, so broadly based that its prosperity is a reflection of the level of activity of the whole of the country's engineering.

With a recovering order book in the later half of the year Hoffmann Manufacturing picked up to finish with a record turnover of business. The order book is now "very healthy" but Mr. Garton reflects that he wishes there were an increased investment by industry in capital equipment.

He sees some indications of a trend in this direction but the emphasis still seems to be principally on consumer goods. The subsidiary BROWN BAYLEY STEELS Limited began the year working below capacity. Although the position improved and by the end of the year the order book was in a good state the demand from railway engineering and some capital goods trades was not up to normal. A satisfactory level of production in most departments is forecast for the remainder of this year.

The year's trading profit of Hoffmann Manufacturing rose by more than half a million pounds to £1,958,302.

Good and not so good for AEI

During the next ten years the electrical industry as a whole will be a growth industry. And ASSOCIATED ELECTRICAL INDUSTRIES will increase its share of that growth.

These are the words of Lord Chandos, the AEI chairman, making the annual review of his more than £200 million business. They are a message for the future.

In the past year four parts of the great concern were in trouble and Lord Chandos, dealing with each in detail, forecast marginal profits for one, modest profits for another, a steady improvement in the third. In the fourth, nuclear energy, no more precise estimate could be given than the £750,000 set aside from the year's trading profits to provide for losses.

Taking the trouble spots singly: cables, telecommunications, lamps and lighting and nuclear power stations, the chairman declared that the price cutting below cost in standard types of cable had led to a great deal of re-thinking by the whole industry. When a competitor, BRITISH INSULATED CALLENDER'S CABLES, raised its mains cable prices, AEI followed, and so it seemed, had the other cable makers. Whether this "self-discipline" would continue Lord Chandos did not know, but he rather thought it would.

The effect of the price war on AEI was an adverse effect from cables upon the trading profit of £1·4 million. But by concentration of production in four plants, Woolwich, Gravesend, Birtley and Lydbrook, instead of six, quality cables can be produced as cheaply as anywhere else in the country. Marginal profits are expected this year.

The result for the telecommunications division of the cut-back in Post Office orders was a contraction in the labour force and a reverse from profit to loss equal to £722,000. It is hoped that the revised Post Office administration may lead to the longer term knowledge of that department's plans without which production cannot be satisfactorily planned.

Temporary relief for the telecommunications division should come from its share in increased telephone equipment orders from the Post Office and in trade which will flow from loans made by the British Government to Ceylon and to Malaya.

For 1960—modest profits.

In lamps and lighting the next two years will see the completion of rationalisation. The present inadequate return on the investment in this sector is expected steadily to improve to a satisfactory level.

Nuclear

Lord Chandos warned last year that a loss would be made on the Berkeley nuclear power station and this now appears certain. The £750,000 set aside from the trading profits to cover the losses is "the right sum which prudent people would set aside in the present state of knowledge" and no more precise estimate is possible.

Whatever the trading figures AEI is here taking part in pushing forward the boundaries of industrial power and knowledge and ensuring its part in a key sector for the furthest advance of the electrical industry.

Among the more cheerful chapters of the AEI story are those on electronic apparatus where a satisfactory position was maintained and there are brighter prospects for this year. The Plastics company has a greatly expanded order book. The Heavy Plant Division has a very healthy appearance although orders were held back in 1959 because of the election. The Railway Signalling company met a large and expanding demand which will continue for some years.

While the locomotive and rolling stock demands of British Railways are not likely to decrease in the next few years there will still be a need for a "secure home market" when the period of re-equipment is over.

One of the most buoyant sectors of all was that of cathode ray tubes and valves. Selling prices were reduced and profitability maintained by cost reductions, due to technical improvement and large scale output. The Turbine Generator Division had an "especially notable" year, Switchgear was "very prosperous" and in domestic appliances the HOTPOINT Company increased its turnover by 54 per cent. By this month the company will have doubled its output of refrigerators.

Referring briefly to the joint research arrangement concluded with REYROLLE and PARSONS, Lord Chandos made the general point that in the United Kingdom some of the shortage of technical manpower was due to the wasteful use of the resources.

With the trading profit for last year, £11,098,000, almost exactly the same as in 1958, £11,069,000, the chairman looked forward with reserve to "increased profits on our ordinary trading accounts."

Leyland on the Wings of a Dove

Directors and executives of Leyland Motors, the thriving heavy commercial vehicles makers, flew over one and a quarter million miles for the company last year.

Now the chairman, Sir Henry Spurrier, a lifelong devotee of flying and air

travel, has bought a De Havilland Dove executive aircraft. The Dove, which has a range of 1,000 miles and a cruising speed of 180 m.p.h., can carry six Leyland executives about the world with all the luggage they may need.

The chairman's flying interests go right back to the First World War. The picture shows the future Sir Henry Spurrier and the long past Maurice Farman (Short-Horn).

Using the Dove, personnel from the London sales office will be able to fly to the Lancashire headquarters for a meeting, on to the Glasgow works of Albion Motors, and return to London on the same day.

The aircraft has been fitted out with Leyland thoroughness. It has an automatic pilot, visual omni-range navigation equipment, a de-icing system and the most recent radio and navigation methods akin to those installed on the Comets.

Rather beyond the range of the Dove, the Australian Leyland factory is about to send out the first of one hundred underfloor-engined Aberdonian buses for use in Djakarta, the capital of Indonesia. This will be the second gift of 100 Leyland buses by the Australian Government to Indonesia, an example of the Colombo Plan benefitting Indonesia and Anglo-Australian industry.

A Record Order Book for Power Doors

G. D. PETERS, of Slough, Buckinghamshire, who make a variety of transport equipment, and particularly vacuum brake cylinders, have suffered from the BRITISH TRANSPORT COMMISSION'S delay in getting ahead with the continuous braking programme.

Plant and equipment installed for the purpose of producing the vacuum brakes was mainly idle during the last year. Until the BTC goes on with the continuous braking programme a major improvement in the position cannot be expected. This is the situation outlined in his annual statement by the new chairman, Lord Inverforth.

The story is happier in another of the company's specialist products, the power door. Peters' power door gear has been specified in a number of major British Railways' and Underground stock replacement schemes. In this field the order book is greater than it has ever been for the company.

The Peters directors are endeavouring to counter attack the underproduction caused by the poor position in vacuum brake orders by diversifying into other activities and by buying other suitable companies. Lord Inverforth describes the group as still dependent, though to a smaller degree, on vacuum brake orders, with the other products and the activities of the subsidiaries gradually increasing their contribution to the overall results.

AEI (Manchester) win Safety Award

Constant imaginative attention to the safety of their workpeople, especially the youngest, has won for AEI (MANCHESTER) a Georgian inkstand.

An inkstand of outstanding significance since it is the Sir George Earle trophy for a merit worthy contribution to industrial safety. AEI (Manchester) have a long record of reducing their accident rate. It has now been brought as low as one accident in every 200,000 man hours worked at Trafford Park.

The drop over the past 12 years has been from an index figure of 1·13 to 0·46. Special attention is paid by the company to training.

Lectures on various aspects of safety are going on three times a week in different sections. Because of the concentration upon the younger members, who once they acquire a conscious care for safe methods are not likely to forego them, AEI (Manchester) is in the happy position of only rarely having to report an accident to boys under 18.

The trophy is awarded by the Royal Society for the Prevention of Accidents. Their citation refers to: "many years of outstandingly successful efforts to produce a safe place of work for its large number of employees through training, both general and specific, given to all branches of personnel, by the meticulous guarding of hazardous plant and machinery, and in recognition of the generosity of the company in making its help and advice readily available to others in the interests of accident prevention."

The award will be made at RoSPA's National Industrial Safety conference at Scarborough on 27 May.

Machining Metal at Ultra-High Speed

Alloys which retain high strength at high temperatures have created a production problem. Using conventional machining methods, very low cutting speeds must be employed. Either more machines must be bought or faster methods of machining must be employed.

MISSILES and high-performance aircraft require alloys to withstand high temperatures while retaining high strength for structural integrity. These alloys have been produced, but they are very difficult to machine. Conventional tools and cutters can be used, but with tremendous penalties in time and cost. Two methods are available for securing improvements. Either the same methods and tools can be used—although this procedure requires a substantial increase in capital investment, for more machines to compensate for the slower machining rates—or, on the other hand, the metal can be removed faster.

As early as 1950, military agencies and individual aircraft companies in the United States were investigating cutting variables as related to tool life on some of these materials. They were well aware of the problem facing the defence industries if machining speeds on parts and components suddenly shifted from a maximum of 15,000 surface ft per min on the non-ferrous alloys to a minimum of from 20 to 300 surface ft per min on high-strength ferrous and titanium alloys.

INITIAL INVESTIGATION

Investigations by the Lockheed Aircraft Corporation, Burbank, California, USA, at that time were directed towards the theory of plastic deformation of materials under high-impact loadings. This theory indicated that materials had a critical impact velocity which, if passed, caused instantaneous failure under tension loading. It was concluded that, by increasing machining speeds to or above these velocities, it would change the normal relationships of workpiece material, tool material and geometry, and chip. Further, the increase in temperature and types of wear resulting from normal machining speeds and feeds would not occur.

At this stage, Lockheed's California Division production engineering department proposed to the United States Air Materiel Command that they should explore the effects of high-velocity machining on high-strength materials. After evaluation by the Command, Lockheed was awarded an 18 month feasibility study contract. A discussion of the study which was then undertaken is contained in a paper read by Mr. Robert L. Vaughn, producibility methods engineer of the Lockheed Aircraft Corporation, at the 28th annual meeting of the American Society of Tool Engineers on 26 April last.

Eighteen organisations and other sources were visited by Lockheeds to obtain information or past experiences on the subject. These visits made it clear that very little technical effort has been expended in research on ultra high speed machining prior to this programme.

A patent search producing over 130 patents, both American and foreign, revealed nothing particularly pertinent. Another search producing over 300 references revealed that published, and unpublished, experimental and theoretical data from the physical sciences rarely involved phenomena of magnitude such as might occur under the conditions of ultra high speed machining. Use of assumptions frequently compromised conclusions based on theory. This led to differences of opinion among metal cutting investigators.

These preliminary studies indicated that little effort had been expended in research on ultra-high-speed machining and that it would have to be proven by practical experimentation. Accordingly, in order to achieve the range of cutting velocities required for a thorough investigation, a linear-motion explosively-actuated test apparatus was designed and built, consisting of a 20 mm smooth-bore gun barrel, a special loading breach, a muzzle fixture, a concrete gun mount and firing controls.

The muzzle fixture, an extension of the gun barrel, was designed to accept a single point cutting tool in special interchangeable tool holders, with provisions for measuring cutting velocities, forces, temperatures, vibrations and chip formations.

The work pieces were projectiles of special design and were propelled with standard 20 mm hand-loaded cartridges. By varying the type and weight of powder charge and weight of the workpiece, it was possible to obtain any desired cutting speed from 15,000 to 250,000 surface ft per min. A bunker filled with cellotex sheets was used. This allowed the chips to escape and permitted both chips and workpieces to be removed uninjured for further metallurgical testing. Chip velocity was measured. Photographic coverage of chip formation was accomplished through a ½ in diameter hole in the fixture which gave a view of the tool cutting edge and the top section of the projectile workpiece. Pin contactors provided the necessary electrical contacts for triggering recording instruments.

Recording equipment included a recording oscillograph for recording temperatures, forces, and system frequencies at a writing speed of 160 in per sec; two electronic counters for recording projectile velocities before and during the cut to an accuracy of 0·1 ft per sec; two high-gain d.c. amplifiers for use in conjunction with the oscillograph and two oscilloscopes which recorded cutting forces and system frequencies; a master firing console with a warning system and interlocks; and a time interval meter for recording post-cut velocities.

Two types of tool holders were used in the muzzle fixture. One holder was designed to give the utmost support to the tool, while the other was instrumented to record the horizontal and vertical cutting forces in an orthogonal cutting force system. Strain gauges applied in bridge networks were used to record the two components of the force being investigated separately.

Tool-temperature and temperature-gradient readings were made by using iron-constantan thermocouples on the tool bit. Two thermojunctions were formed by accurately spot welding 0·001 in diameter constantan wires to the clearance angle of the tool bit end. Electrical contact was made through tool holder contact screws.

MATERIALS TESTED

Five materials were tested during the programme, four of them in two different conditions. They were:

Material	Condition: Annealed KSI Ftu	Condition: Fully heat treated KSI Ftu
AISI 4340	120	280
AM 350	160	190
Inconel "X"	120	165
6A1-4V titanium	130	160
7075 aluminium	—	80

The major portion of the test was carried out on the AISI 4340 steel. Annealed 4340 was compared with the heat-treated 4340 to establish the effect of heat treatment on cutting velocity.

CUTTING TOOLS

The tools used during the datum tests were ⅛ and ¼ in square high-speed tool steel of SAE T-8 composition. Cutting-tool geometry was maintained at 0° back rake angle and 5° end relief angle. For purposes of comparison, a few tests were made in which the back rake angle was varied from + 10° to − 10° and the end relief angle was increased to 7°. Carbide and Stellite cutters were also used for comparison. In all cases, a cutting tool was used only once, in order to establish a direct comparison of tool wear and metallurgical changes to that of cutting speed. Depths of cut varied from 0·005 to 0·045 in.

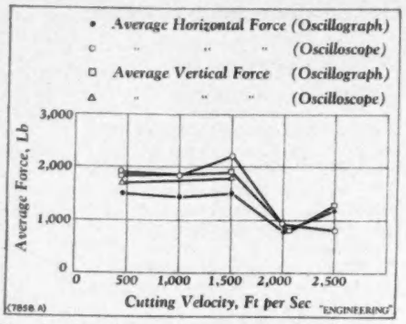


Fig. 1 Correlation of average force with cutting velocity.

To extend data on cutting at high speeds which would supplement the tests made with the gun, cuts 4 ft long were made on the supersonic sled track at Edwards Air Force Base. Conditions for cutting were identical to those of the datum test except that the cutter was engaged in a workpiece eight times as long.

For direct comparison of present-day cutting speeds with those obtained on the test apparatus, machine cuts were made on a conventional toolroom planer at between 40 and 80 surface ft per min. Conditions of cutting were identical to those of the datum test at ultra high speeds except for cutting speed.

RESULTS

The results of these experiments indicate the feasibility of ultra-high-speed machining. No upper limit was found over the range of cutting velocities tested. Statistical analysis of data collected denoted a cutting velocity of approximately 120,000 surface ft per min to be the best for the conditions investigated.

Lockheeds state that brittle or cleavage metal failure did not occur during the tests on 4340 steel, although, in the heat-treated condition, the amount of plastic deformation decreased markedly and the chips became small discrete particles. This was not the case for the other alloys tested. In these instances, all chips produced were in the form of small particles, and brittle fracture could be implied. Generalisation of metallurgical behaviour is difficult owing to the variety of behaviours exhibited by the five alloys investigated.

ADIABATIC SHEAR

A critical impact velocity, as suggested by theories of plastic wave propagation, was not encountered and other mechanisms were sought to explain the observed behaviour. The experimental results do support one mechanism to explain the observed metal separation behaviour —that of adiabatic shear. This means that, as the velocity of machining rises, an adiabatic condition is approached in which thermal energy is restricted to preferred slip planes. Because of weakening in these preferred slip planes, additional slip occurs resulting in complete shear.

Although this mechanism applies to both annealed and heat-treated 4340 steel, comparison of the two conditions emphasises important dissimilarities in behaviour. Annealed projectiles displayed work hardening of the machined surface and of the chips. Distortion of the chips was severe, and only at very high velocities was transformation to martensite visible at the

machined surface of the projectile and in the chip interface. In the heat-treated projectiles, formation of martensite occurred at all velocities of machining and was observed again at the machined interfaces of projectiles, chips, and in shear planes of chips. Distortion of the microstructure appeared less.

Examination revealed that slip occurred in many shear planes in the annealed material and that thermal energy was localised in adjacent planes only at the highest velocities. In the heat-treated 4340, slip occurred in fewer shear planes and the plastic deformation was less. These observations seem consistent with the expected properties of the steel. Work hardening is expected to occur in annealed 4340 and the process of slip transfers progressively to new

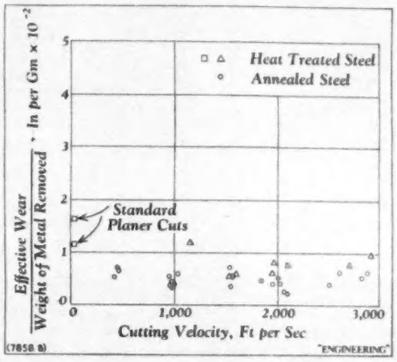


Fig. 2 Effect of cutting velocity on wear per gram of metal removed for deep cuts in SAE 4340 steel (annealed and heat treated).

shear planes; whereas, in the heat-treated steel, slip, once initiated in planes of maximum shear stress, continues because of localised thermal effects. Work hardening then does not occur in the heat-treated projectiles or chips.

Chips from annealed 4340 specimens showed no change in hardness over a machining range of 27,000 to 170,000 surface ft per min, but over the latter figure an increase was observed due to phase transformation. The heat-treated 4340 ship specimens showed little change over the complete velocity range studied. It was concluded that this condition does exist—over a wide range of cutting velocities—where the shearing force does not increase and, most likely, decreases.

CUTTING FORCES

Force measurements made on annealed 4340 steel indicated no appreciable difference between horizontal and vertical forces throughout the velocity range tested. Both force components decreased approximately 50 per cent as velocity increased from 90,000 to 120,000 ft per min. This is shown in Fig. 1 which is a plot of average cutting force against cutting velocity. It is significant that the vertical force, when cutting heat treated 4340 steel, was approximately three times as large as when cutting annealed material while the horizontal force remained about equal. Other data plotting indicated that the ratio of cutting force to area of cut, as well as tool wear per inch of cut, was less for deep cuts than for light cuts. Deep cuts were defined as the ratio of weight of metal removal in grams per in of cut length to be greater than 0·18. This selection was made during the statistical correlation of the test data and was based on scatter characteristics.

CUTTING TEMPERATURES

The results do not support an indefinite temperature rise theory. Excessive oxidation and gross melting did not occur and there was no evidence of heat discolouration on the machined surface. An attempt to find correlation between the temperature rise and other machining parameters was not particularly successful; the most significant conclusion being that the temperatures were not excessively high.

Maximum heat effect on cutting tools was limited to a superficial layer having a depth of approximately 0·0002 in, with no noticeable increase with changes in the velocity of cutting. It can be concluded, therefore, that the amount of heat generated does not increase in direct proportion to the cutting velocity. There is, on the other hand, no indication, that temperature decreases at any particular velocity. The mechanism of adiabatic shear would tend to limit the increase in the heat generated. By this mechanism, finite rise in localised temperature does not require a substantial increase in the total heat generated. Moreover, there is no

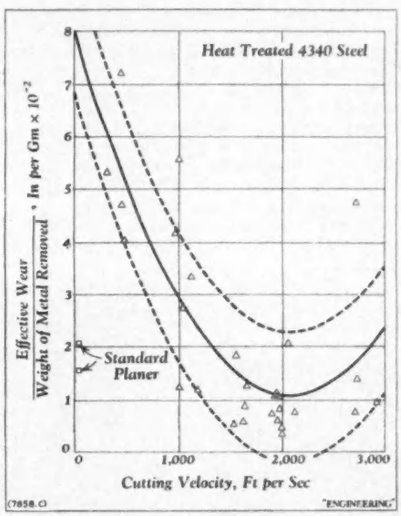


Fig. 3 Effect of cutting velocity on wear for heat treated SAE 4340 steel.

evidence to support the theory that frictional forces between the tool, projectile, and ship significantly add to cutting temperatures.

SYSTEM FREQUENCIES

High system frequencies (up to 1·5 megacycles) were recorded during testing. These frequencies resulted in workpiece striations which were correlated in part, to shear wave reflections travelling at an approximate speed of 804,000 ft per min during machining. This wave is initiated during cutter workpiece impact and reflects at the free end of the workpiece. The reflected wave then meets the cutter and a striation results. After several reflections the amplitude becomes small, probably due to damping.

TOOL WEAR

The relation of tool wear per gram of metal removed to cutting velocity indicated that minimum wear was encountered at a cutting velocity of 120,000 surface ft per min, and, on heavy cuts, tool wear was about the same when machining heat-treated or annealed materials. These facts are illustrated in Figs. 2, 3 and 4. To each graph a second order polynomial curve was fitted by the method of least squares. Some 20 other fuctions were found to fit the data equally as well as the second order polynomial used. The data from the conventional planer cuts are plotted for comparison.

Effective tool wear—distance between crater top and straight edge along the tool's cutting edge with tool in normal cutting position—was used as criteria of tool wear in that it took into consideration both the face and flank wear. A plot of flank or face wear versus cutting velocity indicated the same trend. Tool bit flank wear was generally greater after machining heat treated 4340 steel and face wear was greater after machining annealed 4340 steel. Effective wear was dependent only on cut velocity and depth of cut. Based on limited tests, tool grind geometry appeared to have little effect on cutter or machining performance as compared with cutting velocity. The stellite and carbide cutters tested appeared to offer less resistance to impact loading than did the SAE T-8 high speed tool. It is significant to note the difference in tool wear between heat treated 4340 machined at conventional speeds and at very high speeds—a 5,000 to 1 increase in machining speeds resulted in most cases in equal or less wear on the tool bit.

No tool wear was encountered when machining 7075 Aluminium at 120,000 surface ft per min. Surfaces obtained on the cut surfaces ranged

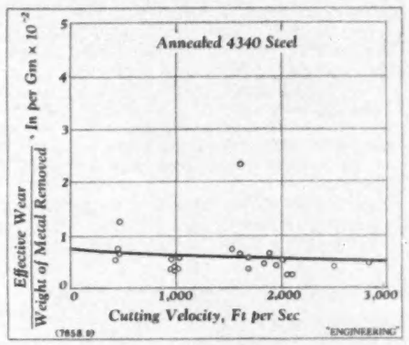


Fig. 4 Effect of cutting velocity on wear for annealed SAE 4340 steel.

from a low of 3 to a maximum of 99 μ-in CLA with no significant variation due to cutting speed.

THE FUTURE

As a matter of conjecture it can be discussed how tomorrow's machine tool might be designed. When centrifugal forces in the type of envelope required for adequately supporting rotating spindles and cutters are considered, rotary motion is indicated to be much more of a problem than achieving the velocities contemplated through linear motions. It is recognised that sharp contours and pockets present problems of a peculiar type. Once it is illustrated that a certain mode or type of cutting lends itself best to ultra high speed machining, the details of specialised cuts would have to be worked out. It is within the realm of possibility to generate contours by incremental cutting.

Vibrations will have to be controlled. Materials are already available and more are being developed which exhibit high damping characteristics.

It is considered feasible to use air bearings or electro-magnetic fields to support high speed spindles. High horsepower d.c. motors without commutators or slip rings in the electrical design show possibility. Gas turbines would be considered as prime movers—these could be used with flywheels to gain the inertia effects for machining. New types of drives and spindles would be considered.

In conclusion, Lockheeds consider that the excellent surface finish and reduction of cutter wear at increased cutting speeds point to the fact that there is much to be gained by the vigorous pursuit of basic data and experience pertaining to ultra high speed machining, Although extrapolation of the data from one alloy to another is impossible at this time, it does not preclude utilisation of the process. The overall results of this study make it readily apparent that the original objectives should be pursued. The data obtained should be further developed, formulated, refined, and applied to the design of a new generation of machine tools for the coming space age.

High Efficiency from Low Grade Fuel

Large electric power stations, using low grade fuel, are a feature of the Central Electricity Generating Board's operating plan. Ferrybridge "B" power station is the latest to come into service.

MODERN power stations must have large and unfailing supplies of fuel and cooling water and, if coal fired, a convenient means of disposing of ash in large quantities. In addition, they must be so sited as to get their fuel with the lowest possible transport charges; consequently, the modern plan is to build the power stations on the coalfields. Finally, in a country which is now very conscious of the effect its industrial buildings may have on the general appearance of the countryside and has made it a legal offence to pollute the atmosphere, attention has to be paid to appearance and cleanliness of operation.

Big boilers and big generating sets, giving higher operating efficiency, are the rule today, and Ferrybridge B power station has three boilers, each of 760,000 lb per hour capacity, and three 100 MW turbo alternators. The fuel used is coal of low calorific value—about 9,700 Btu per lb., compared with the national average of just over 10,400 Btu per lb. Because the power station is near to the collieries which supply its fuel, however, transport charges are low, and the station has a good figure for the cost of fuel and handling per unit of electricity sent out—about 0·315*d* per unit is the average.

Ferrybridge B power station is in south Yorkshire, adjacent to a heavily industrialised area, and has several collieries within a short distance. Fuel can be brought in by rail from the main line of British Railways between Doncaster and York, by 200 ton barges on the navigable River Aire, or by road, the power station coal handling plant being designed to deal with any of these means of transport. Coal can be received at a rate of 250 tons per hour, irrespective of which of the three possible means of transport is used. It can be taken straight to the boiler house, or stocked in an adjacent storage area having a capacity of 220,000 tons.

Cooling water is obtained from the River Aire, and there are three concrete cooling towers to supplement the cooling facilities in times of low water availability. The problem of ash disposal is simplified by the existence of an extensive area of natural floodland to the north of the power station site. Ash and dust are collected from several points in the boiler furnace and gas system, and taken to an ash sump. From this point centrifugal pumps and twin ash discharge lines take the waste product a distance of about a mile to the floodland, where it is scientifically deposited in "bunds" to act as fill. The site of the power station itself was originally at low level and liable to flooding, but was raised to a higher level by means of ash from the older Ferrybridge A power station nearby.

APPEARANCE

Buildings to house heavy plant are inevitably of massive size, and are naturally noticeable in a district where, as at Ferrybridge, small-scale patterns are the rule. Considerable attention has therefore been given to the external appearance of the station, and a landscape treatment has been designed which will, in time, overcome the incongruity. Meanwhile, the appearance of the buildings is simple and impressive. The boiler house—the largest of the buildings—is clad with asbestos to match the cooling towers, but its bulk is relieved by a pattern of small windows of corrugated glass. This form of cladding has the advantage, too, of being relatively cheap to install and maintain, and gives good natural lighting in the boiler room. Each of the three generating sets is arranged with its long axis opposite a boiler, and the result of this layout is a wide but compact turbine house instead of the more usual long narrow building. It is built of reinforced concrete with a five span barrel vaulted roof, and a long mullioned window at the end opposite to the boilers. Again, the natural lighting is excellent, and the cleaning and maintenance of the building are facilitated by the simple design. Offices, service and welfare buildings of red brick adjoin the turbine house, and the upper floor of this block is occupied by the control room, which has double windows overlooking the turbine house.

The building volume works out at 31 cu. ft per kW of plant installed, and the overall cost of construction was about £49 per kW of plant installed.

UNIT OPERATION

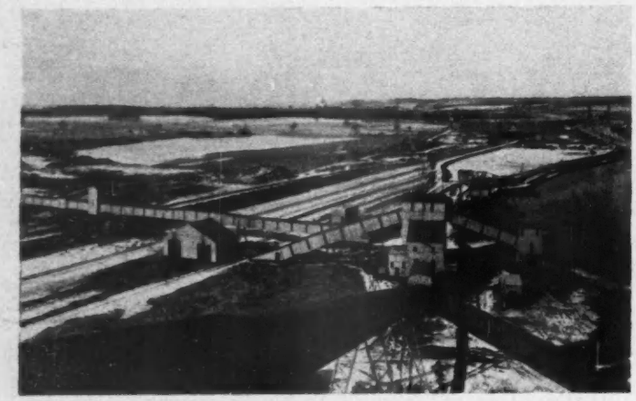
Ferrybridge B power station is designed for unit operation, each of the three boilers and generating sets forming a unit entirely independent of the other two, and there are no cross connections between the steam and water systems of the boilers. The three boilers were supplied by Babcock and Wilcox Limited and the Stirling Boiler Company Limited; all are of the same type—single drum radiant reheat pattern—capable of working at 1,600 lb per sq. in and 985° F. After the steam has expanded through the high pressure stage of the turbine it is returned to the boiler and reheated to 955° F at a pressure of 432 lb per sq. in. Mechanical and electrostatic gas cleaning equipment is installed to deal with the flue gases.

All three turbo generators, which generate at 13,800V and have a rating of 100 MW each, were supplied by C. A. Parsons and Company Limited. They are of the three cylinder type with combined i.p./l.p. cylinder and double flow l.p. cylinder.

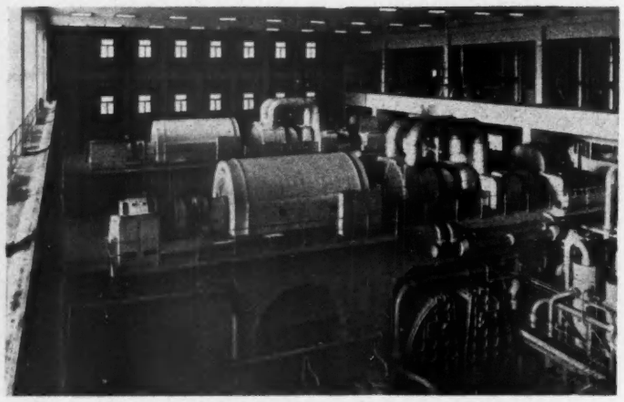
Condensed steam is removed by electric pumps and three Le Blanc rotary air pumps are used to extract air from the feedwater system. After leaving the pumps the water passes to feed heaters and thence to a combined de-aerator and feed heater which removes any gases dissolved in the water. Two booster pumps pass the water to three high pressure feed heaters and it finally enters two 100 per cent duty main feed pumps, driven by 900 h.p. motors. Make-up is supplied by three double-effect evaporators.

Each boiler and turbo-alternator is controlled from its own unit control room at operating floor level between the turbine and boiler. Indications of all operating data are available at this point, and any faults in the system are indicated visually and audibly. Control of the station as a whole is from the main electrical control room, which overlooks the turbine house. Switching, synchronising and loading of the generators and control of the switching stations are carried out by control engineers in this room.

Ferrybridge B power station buildings are designed both for appearance and ease of construction and maintenance.



Coal supplies can be received by rail, road or river barge, and sent direct to boilers or stock.



Two of the three 100 MW turbo-alternators and one of the unit control rooms are visible here.

Safety in Tunnel Construction

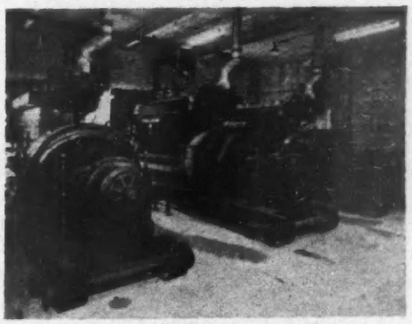
When work started on the twin road tunnels under the River Clyde between Whiteinch and Linthouse, Glasgow, the contractors found that the ground in the approaches was so porous that it would be impossible to pump the water out of the workings. It was therefore decided to pressurise the tunnel to keep the water out altogether instead of attempting to pump the water to the surface.

The first of the two road tunnel tubes is now under construction and due for completion at the end of next year. Work on the second tunnel will be started when the first one is finished.

A pressure of 50 lb per sq. in is used, and a large volume of air is forced in, keeping the water out and providing ventilation at the same time. Failure of air pressure could bring disaster, and the contractors, Charles Brand and Son, have taken elaborate precautions to ensure that safety for men and works is maintained at all times. Thirteen electric motor driven air compressors are used, the electricity supply being brought in from two independent mains.

As a further safeguard, in the event of complete mains failure, 270 kW diesel generating sets are installed. These consist of 6-cylinder turbo-charged radiator-cooled engines made by Blackstone and Company Limited, Stamford, coupled to alternators built by the Electric Construction Company Limited, Wolverhampton. The sets are on anti-vibration mountings and are started by compressed air.

As a further safety measure, a Blackstone automatic mains failure set is installed. This can give emergency lighting in the case of mains failure to allow the workers to leave the tunnel, and to give time for the diesel generators, which are under manual control, to be started up.



In the event of mains failure, emergency power is provided for the pressurising equipment.

Grain Carrier into Car Carrier in One Day

Ships carrying motor cars for export usually bring back other cargoes on their return voyages, so the installation of permanent fittings in the ships' holds to accommodate the cars is impracticable. A typical ship takes cars to North America and brings grain back to London; it must obviously have clear holds for the east-bound passage. At one time, cars were exported in crates stacked in the hold, but apart from the expense of this method, vehicles were often damaged as a result of movement of the crates in bad weather. Tubular steel scaffolding was therefore used, with timber floors mounted on it to carry the cars, but the disadvantage of this method is the time taken to dismantle the scaffolding after the ship has been unloaded. To remove such a temporary structure takes from five to eight days—an expensive item in the running of a ship, which is costing money and earning nothing unless it is at sea carrying cargo.

A new system of hanging decks, developed by Fisher and Ludlow Limited, Material Handling Division, Birmingham, 12, provides false decks which can be dismantled in a single day by the ship's crew even after the ship has put to sea. Known as the " Carflow " system, the equipment will enable a ship to carry more cars than by using scaffolding—20 per cent more, for example, in a 13,000 ton ship—and also has applications for other types of cargo. Carflow has been approved by Lloyds, and the approval of the Ministry of Transport is also expected shortly.

Decks of open steel gratings hang one below the other, in the hold, 6 ft apart, on chains or hawsers. There may be three or four of these decks, depending on the depth of the hold. Guide brackets and channels locate the decks, and wedges hold them in position and make the whole structure rigid when loading is complete. In the hatch openings the panels are mounted so that half the opening is left clear to enable cars to be loaded. As each deck is loaded, the cars are lashed in position, and the open area is closed by further panels, on which the loading of that particular deck is completed. A small deck can also be hung in the upper batch to accommodate low silhouette sports cars, so using all the available space.

After unloading, the deck units in the hatch openings can be hoisted by the ship's derricks and lashed down on the main deck. Alternatively, they can be made in units of suitable size for placing on the hanging decks so that they can be hoisted with the decks for stowage on top of the ship's holds. Further, when the return cargo is grain, the centre panels can be fitted vertically between the bulkheads and round the hatch openings. Covered with light gauge steel sheet they then form shifting boards which, with a bulk grain cargo, the ship must have anyway. When carrying grain, the rest of the hanging decking can be left in position as the grain passes freely through the grating holes.

If the decks are to be removed, this can be done when the ship is at sea between its unloading and loading ports. There is no difficulty in raising the decks, even if the ship is rolling at an angle of 20°.

A set of Carflow equipment has been fitted to the Norwegian ship Ingwi, which was recently refitted at Hamburg, and a modified set is installed in the Bristol City Line ship City of New York. The Swedish ship Willowpool has also been Carflow equipped, and further orders are in hand for Norwegian owners.

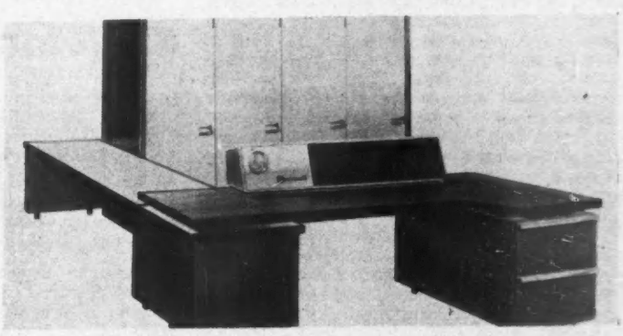
The future of the Carflow system appears to be bright. With car exports from Europe to the United States at a continued high level the demand for shipping space is assured. It is a significant measure of the success of the Carflow design that orders were received from Germany. Numerous alternative systems have been developed by German shipyards in response to direct orders from the car manufacturers, who have been shipping a large volume of their products to America for many years. Nevertheless, the interest in German shipping circles in the Carflow system has been most encouraging. The application of Carflow, costing about £50,000 for a 13,500 ton ship, is not restricted to cars. Any bulk carrier can be converted to general cargo by this means, enhancing the ship's flexibility.

Air Traffic Control by Computer

The first computer to be used for air traffic control is now under construction by Ferranti Limited, Hollinwood, Lancashire. It is of the company's Apollo type, and will be used at the Scottish air traffic control centre at Redbrae, Prestwick, for experimental purposes. The main problem to be solved is posed by the ever-increasing number of piston-engined aircraft flying on the Atlantic routes, and the rapid introduction of turbo-jet aircraft requiring different control techniques. As there may be as many as 100 aircraft in the sky at once, the oceanic controller has to be fully aware of traffic conditions, and re-route aircraft if necessary, to avoid infringment of separation standards. For this purpose, pre-flight planning is essential, and pilots submit a flight plan some hours before departure time. Flight progress strips are then worked out for the controller's progress boards.

This involves much manual work on the part of the controller, and the computer is designed to take over the routine work of planning. It will print flight progress strips relating to each aircraft and provide up-to-the-minute information on air traffic conditions. It will also carry out calculations to see if aircraft are in conflict, and if it is found that separation standards are being infringed, the computer will print details for the information of the controller, who retains the basic responsibility for re-routing the aircraft. The complete situation may also be displayed pictorially to the controller on a radar screen.

The computer will be one of the fastest in operation in Great Britain. Typical examples of instruction times are: simple orders, 6 or 8 microseconds; shifts, multiplication or division up to 60 microseconds. A feature of the machine is that the programme can be interrupted at any time on a priority basis to deal with special situations.



Being built for Prestwick, Scotland, this Ferranti computer will take over the routine work of air traffic planning.

On the Shelf

By Frank H. Smith

It is a source of continual regret to me that I have not the time to read the literature that would make me a Better Librarian. Especially do I feel this way when I see an item such as "Bibliography on Filing, Classification, and Indexing Systems for Engineering Offices and Libraries." It is ESL Bibliography No. 14 and is produced by Engineering Societies' Library, 29 West Thirty-ninth Street, New York 18, for $2. Just imagine how good one would be after reading all those 155 references. There are some intriguing titles, too: "Launching a missile library"; "How would you file rolled tracings"; "Stop playing hide-and-seek with engineering drawings." I'd rather that than postman's knock.

You may not have heard of the revised edition in the "Choice of Careers" series of booklets issued by the father-figure of the Ministry of Labour. It is on librarianship, is priced 9*d* and should be read by those who contemplate a calling rather than a career. (I always think "calling" implies disinterest in monetary gain.)

The latest *Film News* from GB Film Library (1 Aintree Road, Perivale, Greenford, PERivale 7481) contains one or two sponsored films (i.e. buckshee hiring) of interest. Passing briskly over Gillette showing you how to shave we can consider Reed Cartons' "Comprehensive Cover" (mass production of cartons, etc.) and Costain's "Federal Highway" (10 days tour of West German roads) and the same firm's "The Problem Below" (building subsidence. Why? Is it safe to rebuild?). They last for 21, 18 and 30 minutes respectively. Bless my soul, I missed "Magnet"—29 minutes of beer brewmanship by Tadcaster brewery. I'm slipping. I've got some forthcoming attractions but they can wait until they come forth.

What the DSIR describe as a miscellany of foreign technical papers is listed and circularised from Charles House, 5-11 Regent Street, London, SW1. The list before me (Feb. 1960) is German and is coded FDI and it looks as though, having listed it, DSIR more or less washes its hands of the matter. It all seems a bit haphazard and your best course is to send for a copy and work out your own salvation. If you would like a typical(?) title, here goes "Ist die bisherige Methode fur das Erlernen des Maschinenschribens falsch?" to which one may reply ist sie indeed?

A circular letter from the Royal Institution gives me great satisfaction. Its gist is that even though one be not a member, the library is accessible on production of a Reader's Ticket. For information apply to the Secretary at 21 Albemarle Street, London, W1. If you do happen to gain the privilege you will regard yourself as truly privileged, and if you wonder what I mean —wait until you see the library.

Chapman 'n' all's tentative programme includes a 3rd edition of Bray's *Course of Reinforced Concrete Design* at 50*s* (May), *A Modern Outline of Library Classification* by J. Mills at 35*s*, *Manual of Foundry Practice* by Laing (3rd revised) at 50*s* and *Port Operation and Administration*—Bown, Dove and Tooth (2nd edition) at 45*s*. They also do a crowd of electronic books for Rider of America and the Wiley and Reinhold lists. An interesting Wiley appears to be *Structural Mechanics* by S. T. Carpenter at about 76*s*. By the way, C. and H. have ceased to act as exclusive agents for Consultants Bureau and Plenum Press. Future orders should go direct for these to 227 West 17th Street, New York 11.

If any of you are interested in blowing a safe here and there, you may like to read "Recent Advances in Condensed Media Detonations," in American Rocket Society *Journal* for February. It's a review type article with 102 references attached.

The Art of Making Sense

The Teaching of English. Edited by RANDOLPH QUIRK and A. H. SMITH. Studies in Communication, 3, contributed to the Communication Research Centre, University College, London. *Secker and Warburg.* (12*s* 6*d*)

No engineer, who has studied English deeply enough to become a chartered member of one of the institutions which includes an English test in its examination, would hesitate for one moment to parse the headline "Giant Waves Down Liner's Funnel" in two entirely different ways, and thus demonstrate that words out of their context do not necessarily have a definite meaning. Equally, though, he would very quickly be able to parse the following sample of gibberish composed in order to show that the structure of the English language may be demonstrated without reference to the meaning of sentences: "Plome the pleakful croatations ruggle polanians ungleshably in the rit."

If these two samples of the delights offered by this small book are not enough to make every reader of this review want to investigate for himself all six essays comprised in this study in communication, then something is clearly wrong with the reviewer's capacity for communicating the excitement with which it has filled him. Much of what is said in the book has a very serious bearing on the battle at present being waged in Oxford and Cambridge between those who believe that Latin is an essential part of education in a western country, and those who believe that when taught to "O" level and no further it is not merely a waste of time which might be spent on the study of English or other modern languages, but that indeed the study of its grammar may ruin the style of those who may be conditioned by it when later writing in their own language.

The reason that this book landed on the editor's desk was that it contains an essay by the senior lecturer in the presentation of technical information in the department of electrical engineering at University College, London. This essay, entitled "The teaching of English to scientists and engineers," contains much that has long needed saying on English teaching for science students. In particular, it makes the point firmly that any student will become interested in the problems of writing English once he is faced with trying to say something which he really wants to say. At UCL this stage is apparently reached at the end of a student's career when he is faced with presenting the results of a term's work devoted to a small research project. In the reviewer's experience this is too late, since by then "O" level English is 6 years away, and all too many students have forgotten much of what they must have known to pass that essential examination. The problem is how to keep schoolboys and undergraduates interested in the art of writing English. This aim can only be achieved if science masters, and teachers of scientific and engineering subjects, are as critical of the English contained in descriptive technical writing as they are of the scientific content of the passage, so that boys at school and students at the universities and technical colleges come to realise that style and clarity are things which are as precious to the technical man as they are to the arts man. Indeed, they are often more precious, since a well written report may well be the first reason for causing a senior member of an organisation to take critical note of one of his juniors, and the repercussions may be promotion and salary increases.

In an essay on speech education, another contributor discusses the differences between written and verbal communication, and suggests that as we move into an age of more telephones and television, we shall communicate less and less by the written word, and more and more by the spoken. If he is correct, then the necessity for understanding the difference in technique between speaking and writing will steadily increase, and we may all become progressively more aware of the reality behind advertisements that tell us: "His great chance came, but he could only stutter. A month later . . ." Not that this essay discusses how to avoid being frightened when faced by an audience, but it does suggest that the rate at which an audience can absorb new ideas is strictly limited, and that Churchill, rolling out his fine resounding phrases, using all the techniques of the master orator as he repeats in different manners the same idea, is really only giving his audience time to absorb the ideas which he is trying to convey. In the well known advice to those who preach—say what you are going to say, say it, and say what you have said —lies the core of getting a message across, particularly if it is coupled with the other adage: stand up, speak up, shut up.

To anyone who has tried to help a foreigner with problems of English, the essay on "the teaching of English as a foreign language" will also appeal, and it may well bring some light and help to many who have got a smattering of some foreign language themselves, and wish to systematise their knowledge of it, and so to improve it.

This volume is the third to be produced by the UCL Communications Research Centre; the previous one on translation has aroused as much interest as this one will. In a time when knowledge is tending to diversify to the point where no specialist working in one branch of a subject understands what another specialist working in another branch is doing, the work of this research centre is a refreshing change, bringing together as it does the works of many specialists, and deliberately seeking to integrate the different aspects of a whole field. The objects of the older universities are specifically defined as being the pursuit of education, religion, learning and research. For too many years the integration and communication of knowledge has been the ugly duckling, while research has been the beautiful swan. The road to chairs has been through research, not through learning nor through teaching. These volumes, and the work which they represent, hold out hope of a better balance between the functions of a university in at least one field.

D. B. WELBOURN

Skeleton Keys

Hyperstatic Structures. By J. A. L. MATHESON. Vol. 1: An Introduction to the Theory of Statically Indeterminate Structures. *Butterworths Scientific Publications.* (90*s*)

Advanced Structural Analysis. By SIDNEY F. BORG and JOSEPH J. GENNARO. *D. Van Nostrand Company, Princeton, N.J. and London.* (56*s* 6*d*)

The structural engineer is concerned usually with the design criteria of strength and stiffness; the structure must carry the given loads (with some safety margin) and must meet certain deflection requirements. An important third class of problem deals with stability, either of the structure as a whole or of its individual members.

In making an elastic analysis of the strength of a given structure, two distinct processes are involved, although these sometimes tend to get confused; the forces and/or bending moments at each section of the structure must first be determined, and then the resulting stresses calculated. The calculation of forces and bending moments is the process which qualifies for inclusion as a topic of theory of structures; stress calculation is more properly the concern

of strength of materials. Now in the analysis of a statically determinate structure, calculation of forces and bending moments can be made solely by using equations of equilibrium; the analysis may be tedious, but is basically trivial. Theory of structures proper starts when statically indeterminate (or hyperstatic) structures are analysed, and equations of equilibrium alone no longer suffice for the solution. Both books reviewed here deal with this topic of " advanced " structural analysis.

Professor Matheson starts by establishing clearly the two concepts of equilibrium and of compatibility of displacement, on which the whole theory of structures is based, and these two concepts are kept before the reader at every opportunity. The general theorems are developed in this way, and it is pleasing to note how the principle of virtual work is used, and the importance assigned to the theorems of complementary energy. Professor Matheson is not concerned with expounding the trick methods of structural analysis, and, while full prominence is given to standard procedures, such as Castigliano's theorems, moment distribution, slope-deflection equations, and so on, the reader is never put in the position of turning the handle in the hope of churning out an answer. Every procedure is closely and firmly related to the fundamental concepts.

It would be tedious to list the topics covered by Professor Matheson in this very comprehensive book; suffice it to say that the structural engineer will find almost anything he needs. There *are* omissions; for example, conjugate beam theory is not treated, but, on the other hand, the much more important topic of model analysis is given more space than it usually receives in structural textbooks. For this reviewer, the section devoted to plastic theory is disappointingly short. (The same is true of the book by Professors Borg and Gennaro.)

Two former colleagues of Professor Matheson have contributed chapters. Dr. Murray has written a concise account of the stability of struts and frameworks, which draws on recent work in this rapidly developing field. Significantly, the book ends with a chapter on matrix methods by Dr. Livesley. These methods have not usually been stocked in the engineer's armoury, but the weapons are becoming more and more essential with the growing use of electronic computers.

Both in the choice of subject matter and in the way of presentation, Professor Matheson has managed to communicate in this book his great understanding of the behaviour of structures. This *understanding* is not communicated to the same extent in the book by Professors Borg and Gennaro, but then the authors' aim is avowedly different. They wish to expound new as well as standard methods, and the book is addressed to the practising engineer as well as to the student. The American book, although shorter than the English, must contain almost every possible standard method of solution of structures; as such, it is invaluable as a work of reference.

In addition, it contains valuable chapters on torsion of non-circular sections and on slab and shell structures, but does not include discussion of stability problems. Again, the last chapter of the book is devoted to electronic computer solutions of structural problems.

It is very welcome to see the relatively low price of this well-produced American book.

JACQUES HEYMAN

Structural Design for Dynamic Loads. By CHARLES H. NORRIS, ROBERT J. HANSEN, MYLE J. HOLLEY, JR., JOHN M. BIGGS, SAUL NAMYET and JOHN K. MINAMI. *McGraw-Hill, New York and London.* (97*s*)

This book has been compiled from the lectures given in 1956 at the Massachusetts Institute of Technology, covering in two weeks most of the field of structural design for dynamic loads. Problem-types considered, which illustrate the wide scope of the book, are (*a*) vibrations due to machinery, (*b*) impulsive wind loads, (*c*) traffic loads, (*d*) earthquake conditions, (*e*) self-excited oscillations (for example, galloping suspension bridges) and (*f*) blast resistant shelters.

The first two chapters deal with material behaviour under dynamic loading, both steel and concrete being considered, and a firm basis of both elastic and plastic properties is established. (It is of interest to recall that the Morrison shelter in this country was designed by Professor J. F. Baker on the basis of simple plastic theory.)

The next nine chapters are theoretical, and are devoted to the calculation of response of structures to dynamic loading. The analysis is full, clear, and very complicated; for actual calculation simplified methods must be used, and these methods are developed, leading to a discussion of numerical solution of the equations, either manually or with the aid of electronic computers.

Design examples are given in the last eleven chapters. All are interesting, but perhaps the most intriguing for English readers are those on earthquake design. The authors compare Japanese and American practice, and an eight-storey building is investigated thoroughly. The principal application of the analytical work is, however, to blast resistant design, and problems of vibration of girders under moving traffic loads and dynamic effects of wind load are also studied.

The authors do not claim that they have produced a text or reference book. Instead, they modestly intend it as a guide to the engineer interested in dynamic problems and as a survey of the field. As such, it is probably unique, and fulfils its purpose admirably.

JACQUES HEYMAN

The Analysis of Grid Frameworks and Related Structures. By ARNOLD W. HENDRY and LESLIE G. JAEGER. Chatto and Windus. (50*s*)

The structural behaviour of grid frameworks and related structures has recently attracted a good deal of attention. It is surprising to find this type of construction completely overlooked in many text books on the theory of structures, for there are many applications in bridge and floor systems. The authors should be congratulated on their temerity in publishing what is virtually a monograph on the theoretical methods they have recently devised in this field of study.

The book is divided into four sections, the first concerned with the practical procedures for analysis and design utilising the graphed distribution coefficients presented in the final part (the appendix). The theoretical developments are treated in the second section which deals only with pure analysis. The remaining third section reports the authors' model tests as a verification of the assumptions made in the theory, and goes on to consider a selection of published results on actual full-scale or reduced-scale bridges.

This form of presentation is clear and logical, and enables the reader to apply the authors' methods with minimum mental effort; in fact, the procedure for analysis and design can be quickly learned without any reference at all to the underlying theory presented in the second section. The analysis of right and skew bridges, of floor systems with various boundary conditions and of interconnected pinned portals and arches, with torsional effects allowed in most cases, is adequately explained. The design side, however, is treated more lightly, and influence surfaces and worst-loading cases are not really given sufficient attention for the designer. In this respect the attractive illustration on the dust jacket—of an abnormal load crossing a bridge—somewhat misrepresents the contents.

Both Professor Hendry and Dr. Jaeger are very well known for their contributions to structural theory, and their development of Fourier series and the more general " basic functions " to the grid framework problem has been followed with considerable interest in these last few years. Their theory can be widely applied and this makes it all the more attractive and useful. Nevertheless, much of the actual design work in this field is concerned with right bridges, for which the quasi-slab theory, popularised by Professor Morice, can be very usefully applied. It is rather a pity that this alternative method is not considered here; the reader is left to decide the respective merits of these two different procedures himself. This is all the more regrettable since the authors' work on the basic functions has recently been applied to give distribution coefficients for the quasi-slab, so continuity of treatment was possible.

For the skew bridge, however, only the authors' method seems to be available at present, so their treatment is very interesting and valuable; more information would still be welcome and might be considered for the next edition of this work. This sort of design data, expressed as readily used distribution coefficients, is much more useful than the experimental work reported at rather undue length in the third section of the book.

An exact electronic computer analysis is now available for the solution of any grid framework and was reported in ENGINEERING (vol. 187, 1959, p. 666). It may further be used to check approximate and series methods of solution for theoretical accuracy, and to check theoretical assumptions and experimental results more closely (particularly, if stresses, rather than deflections, are compared). The analysis and design of the more common types of grid framework, however, are more easily achieved by means of distribution coefficients as demonstrated in this book. The data in the book will therefore continue to be invaluable for design.

This work can be thoroughly recommended for the further education of every civil and structural engineer, and for the personal library of every bridge engineer.

E. LIGHTFOOT

The Design of Prismatic Structures. By A. J. ASHDOWN. *Concrete Publications Limited, 14 Dartmouth Street, London, SW1.* (9*s* 8*d*)

The adjective " prismatic " is so commonly associated with simple structural members that the average engineer might well expect this book to be concerned with the analysis of structures consisting of such members. But the type of construction considered here is, quite literally, *prismatic* in its simplest form which is that of a roof composed of long rectangular slabs, connected at successive longitudinal edges, so that transverse cross-sections are identical. The alternative description, " hipped plate," which is mentioned in the introduction and is in common usage, particularly in America, is probably more explanatory, however, and applies without confusion to more complicated interconnected slab structures which are no longer prismatic. Such structures may also be described as " polygonal shells " or " folded slabs."

Loading applied *normally* to a slab in a simple prismatic roof is assumed to be carried entirely by lateral bending. The corresponding reactions are resolved in the planes of adjacent slabs. These forces, along with loading in the *planes* of the slabs, produce an overall primary effect which needs to be corrected to give equal stresses on the edges of adjacent slabs at each junction. Equal and opposite edge forces are required to act at each slab junction to achieve this compatibility condition. The values of these pairs of forces can be easily obtained by the implicit or explicit solution of a set of simultaneous equations for the entire cross-section. These forces will usually vary, longitudinally, in an identical manner, if the loading has the same longitudinal variation on each separate slab; thus a single solution at any cross-section leads to an entire structural analysis.

The most elementary form of this theory is based on the assumption of zero linear joint displacements. It is explained here quite well and is applied in three successive chapters dealing with single-span, multiple bay and continuous roof structures. Clearly, the simple beam formula will not apply overall to such structures to take account of the lateral distribution of loading, so this more detailed theory is very necessary. It is surprising, therefore, to find the author, in an early example, reverting partially

Continued on next page

to the simple theory of bending to produce an analysis of a symmetrical two-bay roof, when it is apparent that this particular structure can quite easily be considered as two separate single-bay roofs, identical in structure, loading and behaviour. It may be that the author's method actually gives a better solution compared with a more exact analysis in which linear joint displacements are allowed in the cross-section, but an explanation is needed. A very interesting example on a double trough bunker is also included in this early part of the book, and this should be of considerable interest to reinforced concrete designers.

The fourth chapter is on structures with sloping ends; it is worth noting that analytical solutions appear to be possible for such complex modes of construction.

A new final chapter on "slabs with small angular change" appears in this second edition of the book, and deals with a refinement of the theory for single roof spans, to take account of linear displacements at the intersection of roof slabs. This more exact theory is considerably more complicated, so it seems a pity that a numerically difficult example has been used. The reader is left wondering what errors would result if the earlier approximate method had been applied, particularly if lateral continuity had been allowed before the reactions and the longitudinal junction forces had been calculated (this seems a logical improvement on the procedure used in chapter 1). A 30° deviation angle, or less, between the slabs cannot be taken as anything more than a rather arbitrary criterion for the application of the exact rather than the approximate form of analysis, and more information on the scope of these methods would be useful. But no further references are given.

This monograph is concerned with the analysis of a very interesting type of construction and is clearly a valuable introduction to this topic. It is strongly recommended to all reinforced concrete designers and structural analysts.

E. LIGHTFOOT

An Introduction to Relaxation Methods. By F. S. SHAW. *Dover Publications, New York; Constable, London.* (20*s*)

The basic relaxation technique *is*simply a method for solving linear algebraic simultaneous equations and was originally devised for the analysis of pin-jointed plane frameworks. Evidently this historic fact has inspired the cover artist to use a diagrammative representation of such frames as his *motif*, but the treatment in the book is mathematical rather than physical.

The wide and spectacular application of relaxation methods derives almost entirely from the possibility of representing differential equations by simple finite-difference approximations, which are expressed as linear simultaneous equations, the number in a set depending on the interval size adopted. An increasingly accurate estimation of a function may be obtained as the interval size is decreased (assuming the equations to be solved exactly). Relaxation techniques may be used to solve such equations, the explicit formulation of which can usually be avoided once "relaxation operators" are established.

The time required for the solution of a typical problem depends on many factors, but it is generally agreed that the skill of the "relaxer" is of major significance. This book is intended to give instructions in the art of this form of computing —which is a worth-while technique for most physicists and engineers to learn. It should be noted, however, that the electronic computer can be utilised to perform this labour and can be programmed, in general terms, to deal with many different kinds of problems which were previously dependent on relaxation for solution.

The books by Southwell and by Allen on the relaxation method are already quite well known, but this treatment by Shaw is probably the easiest to understand. It deals very simply first with linear algebraic simultaneous equations, then with finite-difference approximations, linear ordinary differential equations, second-order linear partial differential equations, fourth-order linear partial differential equations, eigenvalue problems, and, in a final chapter, with free surface problems, integral equations, accuracy and non-dimensional treatment. In the appendix a number of very useful coefficients are tabulated for irregular "stars" occurring with ordinary, second and fourth order linear differential equations (for use in curved or irregular boundaries). There is also a chronological list of papers on relaxation, preceding the name and the subject indexes.

As stated in the introduction, this book is almost entirely mathematical in its exposition, so there are few interesting physical examples. The reader is left to idealise his problems himself —this is fair enough, but reduces the value of the book as a quick "lead" on occasional problems.

Relaxation is a procedure which cannot but appeal to the engineer—it is, of course, very closely related to moment distribution. The devices and stratagems of block and line relaxation, for example, are reminiscent of drawing office "dodges." It is rather surprising, therefore, to find the technique known as Liebmann's procedure omitted in the first example, in the solution of Poisson's equation for a square region, and, apparently, in the rest of the book. But, apart from this, the content and development are quite admirable for an introductory textbook. In its cheap paper-bound edition, particularly, this volume is a very useful acquisition for any student or teacher of physics, engineering or mathematics.

E. LIGHTFOOT

New Books

Theory of Mechanical Vibration. By KIN N. TONG. *Wiley, New York; Chapman and Hall, London.* (78*s*)

The outgrowth of university lecture notes, Professor Tong's book is divided into four chapters, covering systems with one, two and several degrees of freedom respectively, and the vibration of elastic bodies.

Handbook of Electrochemical Constants. Compiled by ROGER PARSONS. *Butterworths Scientific Publications.* (30*s*)

A bench and pocket book on ions, salts, solvents, electrolytes and electrodes, with a spiral binding which ensures that the table you need stays open.

The Lead Storage Battery. By H. G. BROWN. 4th edition. *John Sherratt and Son, Park Road, Altrincham, Cheshire.* (24*s*)

The structure, economics, operation and maintenance of these batteries, together with some consideration of special applications, including road and rail traction.

Principles of Modern Building. 3rd edition. Volume 1. Department of Scientific and Industrial Research (Building Research Station). *HM Stationery Office.* (20*s*)

This is a completely re-written edition of a book embodying the experience of some 40 years work at the Building Research Station. The first volume deals with the building as a whole, and with walls, while the second will be concerned with floors and roofs.

Curve Surveying. By R. B. M. JENKINS. *Cleaver-Hume Press.* (35*s*)

A handbook for road and railway engineers and surveyors. The theory has been treated in full for the benefit of teachers. Chapter three gives the relation of safe speeds to circular arcs.

Year Book of the Heating and Ventilating Industry, 1959/60. *Technitrade Journals Limited, 8 Southampton Row, London, WC1.* (15*s*)

Technical articles on the design of pipes and ducts, large poultry houses, and warm air heating systems preface a reference section on byelaws, standards, working rules and conditions of trading, and an extensive buyers' guide.

Industrial Electronics and Control. By ROYCE GERALD KLOEFFLER. 2nd edition. *Wiley, New York; Chapman and Hall, London.* (80*s*)

This new edition approaches the electronic theory of rectification, amplification and oscillation through solid state theory rather than by way of vacuum and gaseous tubes. New material on semi-conductors, servomechanisms, computers and electronic measurement has been added.

Mesure et Instrument de Mesure. By J. IDRAC. 4e édition. *Dunod, 92 rue Bonaparte, Paris 6.* (9 *NFrs*)

A study of measurement and instruments of measurement, concerned with the analysis of the application of individual types of instrument, the calculation and correction of errors, the choice of methods, and the design of instruments.

The British Shipbuilding Compendium, 1960. 10th edition. *Shipping World, Effingham House, Arundel Street, Strand, London, WC2.* (20*s*)

The products and services of more than 1,700 companies are analysed under 317 headings, with an alphabetical cross-index.

Trade Publications

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted

Activities

Agricultural Transformation. VIDAURRETA Y COMPANIA S.A., Saluda, Spain. Booklet *Fifty Years in the Field* tells the story of the change in Spanish agriculture since the days when all machinery had to be imported. (In Spanish.)

Plant Construction. P. G. ENGINEERING LTD., Parkfield Works, Stockton-on-Tees. Project and equipment engineering from design to operation is the title and theme of an illustrated brochure in English, French, Spanish, and German.

Production and Construction. ASHMORE, BENSON, PEASE & CO., LTD., South Works, Stockton-on-Tees. Examples of design, manufacture, transport, and erection of engineering are given in a 56 page booklet.

Who, What and Where. METAL INDUSTRIES GROUP, Brook House, Park Lane, London, W1. The MI Guide (third edition) gives notes on the companies that compose the group.

Cables. ALUMINIUM WIRE & CABLE CO. LTD., 2 St. James's Square, London, SW1. *What Awco Makes* covers the range of cables and conductors now available. A second booklet illustrated in colour describes the spanning of the River Severn by the Supergrid.

Patterns and Moulds. J. J. HARVEY & PRESSURECAST LTD., Lime Bank Street, Manchester, 12. Patterns in wood, tin, brass, aluminium, and iron, and moulds for rubber, plastics and wax. One-off or production runs. Booklet gives examples.

Tool History. SPEAR & JACKSON LTD., Aetna Works, Savile Street, Sheffield, 4. An account of 200 years of steel and tool making is given in a 20 page illustrated brochure.

Group Activities. DAVY AND UNITED ENGINEERING CO. LTD., Darnall Works, Sheffield, 9. The varied activities of the group are outlined in a broadsheet.

Gas Plant. INCANDESCENT HEAT CO. LTD., Cornwall Road, Smethwick, Birmingham. The products of the Gas Atmosphere Division range from filters to ammonia plant and are listed in a leaflet.

The Reviewers

Mr. D. B. Welbourn, M.A., M.I.Mech.E., M.I.E.E., is a fellow of Selwyn College and university lecturer in engineering at Cambridge. He was the first manager of W. H. Allen Sons and Company's epicyclic gearing department, and development manager of Turners Asbestos Cement Company. He has served on the council of the Institution of Electrical Engineers and is also a member of the Verein Deutscher Ingenieure.

Dr. Jacques Heyman is a fellow of Peterhouse, Cambridge, and lecturer in the university engineering department. He is author of *Plastic Design of Portal Frames* and co-author (with J. F. Baker and M. R. Horne) of *The Steel Skeleton* (volume 2). He was visiting professor at Brown University, Rhode Island, in 1957-58 and is an M.A., a Ph.D. and an A.M.I.C.E.

Dr. E. Lightfoot is reader in civil engineering at the University of Leeds. He is a member of council of the Institution of Structural Engineers.

Marketing

Ship orders improve faintly

SHIPPING of 196,000 tons, a total of 53 ships, were ordered at British shipyards in the first quarter of the year. This maintains the slight improvement of the close of last year and is more than three times the weight of orders (53 ships, 55,000 tons) in the first 1959 quarter.

The SHIPBUILDING CONFERENCE points out that a significant feature of the new orders is that much of the work was obtained in the face of intense overseas competition. Shipowners are now being heard to say that British prices are more favourable than those quoted abroad. At least two firms have picked up orders when they had no new construction on their books.

The total order book for the industry at the end of March was 471 ships—4,044,000 tons, of which 773,000 tons were for foreign owners. Although this is considerable there are some yards with coming gaps in their production programmes because of the deferment of existing contracts until shipping earnings pick up more.

Beating the drum for AEI cables

The cable manufacturer gets no free advertisement for his product by its everyday appearance after installation. Soon after emerging from the works the cable disappears from sight and there is an end of it, apart from repairs.

ASSOCIATED ELECTRICAL INDUSTRIES WOOLWICH Group, have been concerned to do something about this and they have now come up with a brightly turned out cable drum painted in a bright yellow and black design. The HENLEY, LIVERPOOL CABLES and SIEMENS EDISWAN parents of the present group are commemorated with mentions—Henley, SES, LEC, around the drum between the massive AEI initials.

German farm factory in Australia?

A German industrial concern is being offered a site by the West Australian Government to encourage them to establish a plant for the manufacture of farm machinery.

Mr. Helmut Claas, a director of CLAAS BROTHERS, of Harsewintel, Western Germany, is at present in Australia looking over the ground. If Claas Brothers take the scheme up it will be their first move into the Commonwealth.

Never Never comes to car batteries

Local garage men and service agents of OLDHAM AND SON, the Manchester battery and accessory manufacturers, are to operate a scheme in which motorists may pay for their heavy duty batteries over six months.

Once the first payment has been made the instalments go to the credit sales department of Oldham's, Denton, Manchester, head office. This administrative detail is likely to earn considerable goodwill from hard pressed garage managers.

BEA passing it on to the passengers

Something of the benefit of BRITISH EUROPEAN AIRWAYS' excellent financial position is to be passed on to the passengers in lower fares.

BEA's total traffic, 130 million tonmiles a year, is now 100 per cent up on the levels of five years ago, compared with a 75 per cent increase in the traffic carried by all airlines.

Lord Douglas of Kirtleside, the BEA chairman, while pointing out that the final figures will be some time in appearing, has said that after paying £1½ million in interest, the corporation made a profit of £2 million. The largest profit so far and the sixth consecutive profitable year.

The important thing about the reductions is that, taken together with the inclusive tour fares brought in last year, they strengthen BEA's hand in its competition with land and sea transport.

The fare reductions vary from the 16 per cent cut in the London-Paris night week-end flight, down from £38 4*s* to £30 9*s*; to the 39 per cent fall in the night mid-week London-Lisbon flight, from £60 12*s* (the old day fare) to £37 1*s*.

Two of the outstanding figures in the traffic figures for the year show that load ton miles sold went up by 19 per cent to 130 million and the revenue load factor increased by 12 per cent to 67·7 per cent.

£500,000 oil drilling platform for North Sea

A £500,000 mobile underwater oil drilling platform, completed on the Tyne and now at Cardiff, is to make three drillings off the coast of Holland next year.

The platform—"Triton"—115 ft long and 80 ft wide, has a d.c. diesel-electric drilling rig. Communications are considerably aided by the existence of a helicopter landing deck. "Triton" will be operated by NEDERLANDSE AARDOLIE MAATSCHAPPIJ (NAM).

Standard Oil (New Jersey) and Internationale Petroleum Maatschappij of the Royal Dutch-Shell Group, each have a half interest in the NAM company.

For drilling, the four legs of "Triton" rest on the sea-bed. The hull can be moved up and down by hydraulic means. The main contract for the platform was carried out by DE LONG, the United States construction company. The hull and legs were contracted out to the shipbuilding yard of CLELANDS at Wallsend-on-Tyne.

Financing growing Australia

The Australian industrial expansion goes on rapidly growing. A cash loan of $25 million is to be raised on the New York market. This will be the fourth time the Australian authorities have gone to New York for money since early in 1958. Last year Australia borrowed £A42,500,000 abroad. She raised two loans in New York, one in London and one in Switzerland.

The money is sought by the Australian Loan Council which coordinates the public borrowing activities of the Federal and State governments.

Growing demand in Western Europe

A continued, and in some cases accelerated, growth in the industrial activity of the Western European nations for the rest of the year is pointed to by the economic survey of the Economic Commission for Europe.

The survey found evidence of growing demand particularly in the three largest Western States, France, Germany and the United Kingdom. Looking further afield the survey says that since there is expansion in Western Europe and in North America and some improvement in the export-earning and financial reserves of the primary producers, demand for the exports of the three main European countries is scarcely likely to do other than improve.

The survey goes on to suggest that the same Western European States may find themselves raising the level of imports more swiftly than of exports. There is another warning here that Mr. Amory, the Chancellor of the Exchequer, may not have been far ahead of events when he said that the Government was ready to take the necessary steps if they were required.

Credit restriction steps taken so far are mild and should in most countries have little effect on industrial activity during the year, according to the survey.

Record car output marred only by strikes

The one and only major car manufacturer not announcing record output in the first quarter of this year is the BRITISH MOTOR CORPORATION.

FORD's, with vehicle exports running at 59 per cent more than the same period of last year, are turning out cars, trucks and tractors faster than ever before. VAUXHALL MOTORS produced 79,000 cars, vans and trucks, another record for the quarter.

STANDARD TRIUMPH–INTERNATIONAL, with production up to an annual rate of 170,000 a year, now has a highest-ever first quarter behind it.

ROOTES and ROVER echo the record theme. Rover are understood to be substantially up on 1959, perhaps by as much as a quarter.

Solartron offices by Taylor Woodrow

TAYLOR WOODROW CONSTRUCTION are to build a five-storey office block and a single-storey factory extension for the SOLARTRON ELECTRONIC GROUP at Farnborough, Hants. The contract awarded to the constructional firm is worth £350,000.

This operation is the second phase of a £1¼ million expansion scheme on a 15 acre site at Tower Hill, Farnborough.

British Motors to begin at Bathgate

With the difficulties about the new Bathgate, Scotland, site for the BRITISH MOTOR CORPORATION'S expansion safely disposed of work on the site of the new factories is expected to start there sometime next month.

The trouble, over the suggestion of the Scottish Home Department that a single access road to the Glasgow-Edinburgh road would be enough, has been resolved by a compromise. Instead of the three roads British Motors would have liked —one each for the new tractor, heavy truck and engine factories—there are to be two roads. One road will be for traffic entering the site and the second for vehicles leaving.

There are hopes in the BMC that tenders for the main works will be out by the end of June.

More jobs by new use for old mill

Expansion and diversification plans put forward by the PAKAMAC industrial group are designed to bring new and greater life to an old Lancashire cotton mill scrapped in the reorganisation scheme.

The mill is the Melbourne Mill, at Chadderton, Oldham. In its textile days it employed 200 or more people.

The Pakamac group, having succeeded in the field of light rainwear, is now moving into the lucrative, if intensely competitive, domestic appliance field and is kicking off with the Pakamatic four cubic foot refrigerator, competitively priced at 52 guineas.

Melbourne Mill will eventually have around a thousand workpeople engaged in the production of Pakamac products. The mill has almost 200,000 sq. ft of floor space.

Japanese buy USA jet airliners

Three Convair 880-M jet airliners are to be bought from the Convair Division of GENERAL DYNAMICS CORPORATION of the United States by JAPAN AIR LINES. They are to be delivered just over twelve months from now.

The Convair 880-M has a maximum cruising speed of 615 m.p.h. and is equipped with wing leading-edge flaps and a power-boost rudder for shorter landing and take-off performance. The first seating layout is for 87 passengers, made up of 28 first class and 59 coach class.

New Crane selling set-up for keener competition

A combined foreign sales effort has been organised by three of the member companies of STEEL AND COMPANY, in the face of increasing competition from abroad in the export market for cranes.

The three companies are STEELS ENGINEERING PRODUCTS, R. H. NEAL & COMPANY, and F. TAYLOR AND SONS (MANCHESTER). They have apportioned their sales efforts in three divisions of the world markets between three new companies.

The BRITISH CRANE Company of London, will handle the sterling area, four of the countries of the European Free Trade Area, and Africa and Asia. The INTERNATIONAL CRANE AND EXCAVATOR CORPORATION, of New York, will tackle the Western Hemisphere and certain other dollar markets. In Europe, a sales company based in Switzerland will promote sales in the European Common Market and in Austria and Switzerland.

Speak-Your-Weight Gas-Holder Station

Telemetry equipment using voice transmission over Post Office telephone lines enables operators to check conditions at the unmanned Newbury gas holder station from any telephone box. The equipment will ring the control office if there is cause for alarm.

I WONDER what is happening at the holder station, said the worried gas superintendent, and lifted the telephone. In a few seconds he could hear a soothing voice assuring him that all was well at the gas-storage plant. The volume in store gave no cause for alarm, the pressure in the supply lines was according to schedule, and the station service electricity supply was normal. Satisfield, the superintendent hung up the receiver.

There is nothing very unusual about the hypothetical situation just related, except that the gas-holder station in question is normally unattended, and at the time of the call there was not a soul there to answer the telephone. Instead, a grey box measuring roughly 2½ ft square responded to the call and made a quick check of all the information necessary to assess the condition of the plant. The box then reported to the superintendent verbally, over the regular Post Office telephone lines. If the bout of anxiety were to overtake the superintendent in the middle of his vacation in the Outer Hebrides, he could find relief with equal ease—provided he can locate a telephone.

If something does get out of hand at the station, the grey box will put in a phone call to the control office to report the alarm immediately. A certain amount of native stubbornness is also incorporated in the design: if the telephone of the control office is engaged, the box will make several attempts to establish contact.

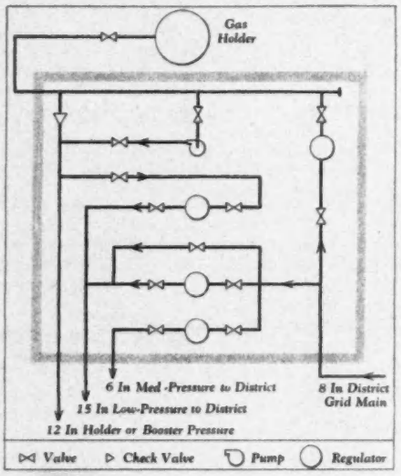
The unusual verbal telemetry equipment is now installed in one of the unattended gas-holder stations of the Southern Gas Board, located adjacent to the Newbury race course. The station is part of the Board's distribution system and includes a 750,000 cu. ft storage tank, flow regulating devices and a booster pump used to increase the distribution pressure when the storage pressure is low. The plant operates on a time controlled distribution programme, varying the pressure in the outgoing lines according to a daily schedule which depends on the expected demand. Filling of the tank is also time controlled. As a result of the simple and inexpensive arrangement the plant can operate unattended provided a periodic check is made to ascertain that conditions do not get out of hand. Daily checks are desirable, and as the station is 17 miles from the control office in Reading, this would entail a trip taking about 1½ hours every day. There are 48 unattended gas-holder stations in the Board's system, about 15 per cent of which require daily supervision.

Data Channels and Alarm Requirements

Item	No. of bands	Alarm
Stock held	10	High, low
Pressure, grid main	10	Low
Pressure, MP line	10	Low
Pressure, district supply	10	Low, at two points
Electricity supply	2 (on-off)	Off
Booster pump	2 (on-off)	If supply pressure low and pump off

To economise in manpower, Mr. F. Bell, the Board's distribution engineer, got together with Sound-Diffusion (Auto-thermatic) Limited to develop a suitably flexible system for possible installation in several stations. The problem is relatively simple in terms of supervisory telemetry: only six independent variables have to be reported. The novelty of the design lies in the method of data transmission. Sound-Diffusion had used Post Office lines for this purpose before, notably for the supervisory control of an unattended electrical generating station of the South Western Electricity Board near Bristol (ENGNG., vol. 189, p. 56). But the Bristol installation uses coded high frequency signals, requiring de-coding equipment to make the message intelligible. As the telephone system is designed for verbal transmission, a wonderful opportunity occurs to streamline data transmission by eliminating the code and using the human voice instead of electronic pips.

The functional parts of the Datafonic equipment which distinguish it from other telemetry installations are a 10 in high fidelity gramophone recording, a turntable and pickup. The first band on the record is the telephone call-signal. With an automatic exchange the high frequency dialling signals are recorded directly on the disc; with a manual exchange, as at Newbury, the recording announces itself and asks for the number of the control office. The call signal is repeated for 90 seconds to allow the operator to react and ascertain the number. The recorded voice then reads ten selected values of the measurements shown in the table starting at the high value and working down, and two reports on the booster pump and the electricity supply.

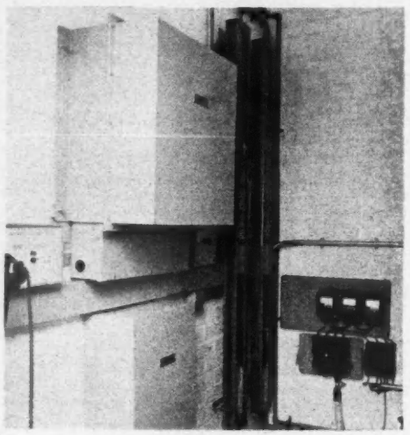


Schematic arrangement of piping at the Newbury gas-holder station, an unmanned installation.

The complete recording, 44 messages plus opening and closing sentences, is played every time the telemetry equipment operates. However, only the relevant portions are passed through the telephone lines, the rest is blocked. To increase sensitivity without lengthening the recording unduly, two announcements are heard if the actual value lies half-way between two recorded values. Thus "District—Seven . . . District—Six" would indicate that the pressure in the district supply line is closer to 6·5 than either 7 or 6 lb per sq. in. The announcements are blocked or passed by circuits which are completed or broken by the manometers, pressure switches or the auxiliary relays in the station electrical supply and the booster pump supply. After each message, a high frequency pip on the recording actuates a relay to change over to the circuit corresponding to the next reading.

The sensitivity is further increased by uneven spacing of the measurements. When conditions are normal the spacing is wide, but when a dangerous condition is approached the spacing becomes narrower and the data more accurate.

Two conditions will bring the Datafonic equipment into operation: either an external call, or an alarm condition in any one of the six measurements. A further refinement is designed so that an alarm message will not get lost. The last sentence on the recording is "Please acknowledge now." An uninterrupted high voice-frequency signal lasting three seconds serves as acknowledgement; this can be produced by means of a suitable buzzer or by whistling into the telephone. Unless the alarm message is thus acknowledged, the Datafonic robot will make attempts again and again to get the message through. In agreement with the Post Office, the number of attempts is limited to seven, after that the machine just gives up.



Heart of Datafonic with relays and record player in top, dry batteries in bottom cabinet.

The Datafonic equipment is not limited to Post Office telephone lines, it could be used with minor alterations on private lines, radio links, or power line carrier circuits. The choice of Post Office service in the case of the Southern Gas Board's application is justified on simple economic terms. Private telephone lines cost around £12 per mile per year. Newbury is about 17 miles from Reading, giving an annual charge of £204. A telephone call from Reading to Newbury costs 9*d*, and it is believed that about two calls per day will be required. The annual cost will be in the order of £28.

Although the Newbury installation is purely supervisory, at a 30 per cent increase in installation cost some remote control facilities could also be introduced. The voice recordings would remain the same, but at the end of the transmission the machine would not break the line but wait for coded audio-frequency control signals.

The entire electronic circuitry operates on transistors, and an independent power supply consisting of a bank of dry batteries is provided, so that data transmission can proceed even after failure of the station electrical supply. It is believed that the vulnerability of Post Office telephone lines is no greater than that of private lines, and in addition faults can be traced quickly. Once a faulty line is recognised, appropriate measures can be taken by the operating staff to visit unmanned stations.

The equipment produced by Sound Diffusion is designed as a standard assembly with plug-in components. To allow for minor variations in station layout or telemetry requirements, an accessible patchboard is provided in the cabinet. The recording itself has a life expectancy of about a thousand transmissions which would last over a year at the Gas Board's installation—provided not too many curious people ring up Newbury. For this reason the Gas Board is reluctant to release the number although those sufficiently interested can of course obtain it from Directory Enquiries.

Continuous Control of Viscosity

Since laboratory checks of viscosity during blending are tedious and require extremely accurate temperature control (a difference of 1° F represents a change of about 10 per cent in viscosity) an automatic controller has been developed by Smith's Industrial Instrument Division Chronus Works, North Circular Road, London. NW2, that regulates blending to an accuracy within ± 2 per cent and a response time of 2·5 sec. Blends down to 200 sec. Redwood No. 1 can be made.

Its principle of operation is that, by the use of two viscometers, the viscosity of a sample from a pump line is continually balanced against the viscosity of a sample prepared in the laboratory. The viscosity of each sample is measured by a rotating cup viscometer, the output torque of which acts upon a balance arm. Both these viscometers run in a water bath and are driven at the same speed by an electric motor. The laboratory tested sample in its viscometer is at the temperature of the bath, and the sample from line quickly attains that temperature as it passes through the heat exchanger, which is also immersed in the bath. (Although the precise heat of the bath is not important, as the viscosity of each sample is measured at the same temperature, in practice it is increased when dealing with products of high viscosity, in order to reduce torque to a reasonable value).

Clearly then, with each identical viscometer running at the same speed and temperature as the other, if the viscosity of the standard sample is the same as the viscosity of the product under test, the viscometers' torques will be equal and the balance arm will be in a state of equilibrium. From this it follows that a change in viscosity of the line product will cause the balance arm to move and in doing so operate a micro switch or a pneumatic control.

As manufacturing tolerances prevent two viscometers having exactly the same gaps between moving and static elements, an adjustment is provided for the fulcrum of the balance arm. Identical samples are run through the viscometers while adjustment is made to achieve balance.

A standard sample having the desired viscosity of the product is fed by gravity through a filter (not shown in the diagram, Fig. 1). Introduced to the sample viscometer through pipe (1), it passes to the lower bearing spigot and cross passages, and from there to the space around the outside of the rotating drum. Finally, it enters through the peripheral holes drilled around the mid-point and fills the annular space between the rotating drum and the measuring drum.

Oil from the blending line enters the strainer (2), through the pipe connection (3), and thence flows through the pipe (4) to a pump. The strainer has a very small capacity: a large capacity would unduly delay the signal that indicates change of viscosity. The pump (5) is introduced mainly to isolate the apparatus from the line pressure. Oil passes through the pump, enters, the heat exchanger via the pipe connection (6)

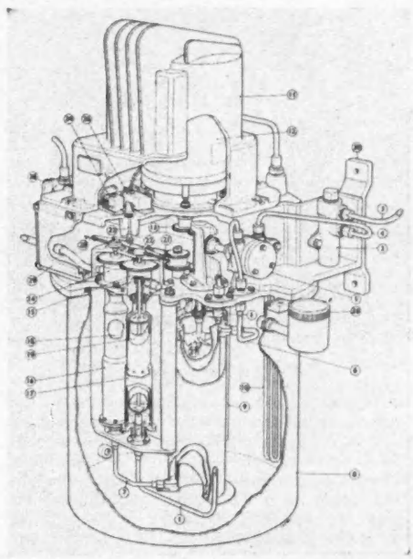


Fig. 1 (above) Cutaway diagram of the viscosity controller.

Fig. 2 (right) The controller (at left) installed in a refinery. A mixer is mounted on the pipeline to ensure a good blending before sampling. On the right is the regulating valve operated by the controller.

then flows through the connection (7) into the in-line viscometer. The heat exchanger is provided to ensure that oil from the line is raised to the same temperature as that of the standard sample in the shortest period possible—approximately 5 sec.

The heat exchanger consists basically of two concentric metal sleeves. Oil from line is forced through the annular space between them, while water is circulated by means of the impeller (27), through the inner sleeve and the water jacket surrounding the outer sleeve.

Temperature of the water bath (8) is maintained by means of a thermostat (9) governing a heating element (10). The exact temperature is not important, but it is set to a figure that ensures that the viscosity of the line sample, and hence the torque produced at the viscometers, is not unduly high for the type of mechanism. Water is used for the bath, and in conditions where extremely low temperatures may be expected an anti-freeze resolution is recommended. The water bath is topped-up through the filling cap (26) to a line engraved below the optic.

The electrical side of the controller is of flame proof construction and the apparatus may be used with confidence in hazardous atmospheres. The top cover (11) is cut away in the diagram to reveal the driving motor (12). This motor drives the spur wheel (13), which in turn drives the pump (5) and rotating outer sleeves of the viscometer (14 and 15).

The oil then passes to the viscometers, where rotation of the outer cylinders (16 and 17) causes a viscous drag on the inner, or measuring cylinders (18 and 19). This torque is applied to the arms (20 and 21), which act upon the balance arm (22). Excessive stresses are obviated by the use of lengthy arms, so that frictional forces on the central pivot of the balance arm are minimal. Motion of the balance arm is transmitted through the shaft (23) to operate the micro switches (24 and 25).

An important constructional point is the method of sealing the shafts from the sensitive cylinders to the balancing mechanism. In this application, it would be quite valueless to provide conventional seals because with some low viscosity products an out-of-balance torque of a mere 2 gm would represent a viscosity change of 1 per cent.

The viscosity controller depicted in the diagram is a simple "On-Off" electrical type, and the micro switches in this application would be used to control a relay box, and hence a motorised control valve in the blending unit. For pneumatic control, the micro switches would be replaced by a drive taken from the balance unit, by bevel wheels, to a pneumatic controller.

The terminal box (28) is of flameproof construction and is arranged for Pyrotenax connection. Access to the mechanical balancing unit may be gained by removal of the cover (29).

Fastenings for Interior Tiles and Fittings

A new range of fastenings has been developed by Simmonds Aerocessories Limited, a member of the Firth Cleveland Group of Companies, known as Spire Speed fastenings. These may be used for securing a wide variety of interior fittings, the design of which is thereby simplified. Among the many successful applications are the fixing of suspended ceilings, acoustic tiles, insulation board, small-bore heating pipes, electrical installations, built-in furniture and partitioning.

All Spire Speed fastenings are self-locking against the effects of vibration and are designed to provide a speedy and inexpensive method of assembly. The available range comprises a total of over 800 different designs of clips, nuts and push-on fixes using an unthreaded stud. Many of these are suitable for "blind" assembly in cases where access is only possible from one side, for example, when securing wall or ceiling panels.

In addition to their standard range the firm also regularly produce specials for customers with peculiar problems.

The builders of the London Planetarium used a considerable number of standard push-on Spire fixes for attaching the Rocksil acoustic lining to the interior of the main concrete dome. In this type the fix is embedded in a decorative polythene cap, which is pushed on to an unthreaded stud protruding through the panel.

An interesting example of the use of Spire specials is provided by Frenger Ceilings Limited, who manufacture a suspended and removable sub-ceiling with radiant heating and sound absorbing properties. The ceiling itself consists of metal panels clipped by means of a special Spire fixing to ¾ in O.D. hot water pipes, over which are laid Fibreglass insulation sheets. The whole is suspended 2 ft below the main roof, allowing space for service piping and other installations. Each panel of the Frenger ceiling is made removable for maintenance of the services above it, and the Spire fixing has accordingly been designed for ready freeing and subsequent re-attachment from beneath.

Why Test Reports on Cars Vary So Much

The characteristics of a vehicle depend on how and when they are measured. Greatest variation of assessment is found in subjective judgment of qualities such as ride and handling. Standardisation of all aspects of car measurement is called for.

THE difficulties in making an accurate assessment of a car are discussed by the Director of the Motor Industry Research Association, Dr. A. Fogg, in a paper "Performance Measurement of the Complete Car." It was one of the Crompton-Lanchester Lectures delivered to the automobile division of the Institution of Mechanical Engineers. In spite of the growing range of scientific measuring techniques, any conclusions reached about the performance of a car will involve subjective as well as objective assessments. Among the objective measurements possible are speed, acceleration, and fuel consumption. But even these are difficult to standardise. Subjective aspects, depending largely on the opinions of drivers and passengers, include riding comfort, ease of handling, and to a lesser extent noise.

Fuel consumption is a good example of a measurement that is apparently simple but which is fraught with controversy. The arguments arise because fuel consumption is not a characteristic of the car alone. It depends on the driver, the road over which the test is made, the traffic conditions, and the weather.

In spite of being such a complex function, the value of fuel consumption is frequently required for working out the economics of vehicles and for deciding the effect of modifications. When large fleet operations are concerned, for example, a group of public service vehicles, probably the only satisfactory procedure is statistical analysis of vehicles in service. This procedure has been used with considerable success in determining the effect of a change in engine oil viscosity. Unfortunately the method is not usually practical for private cars, or for the development of prototype cars.

For such situations it would seem to be preferable to adopt a standard procedure, measuring fuel consumption under different specified conditions. Generally, the fuel consumption of a vehicle will be within a certain band, the boundaries of which can be determined accurately. For convenience, these may be termed "maximum" and "minimum" consumption rates, and are lower and upper boundaries of the shaded area in the accompanying diagram.

The upper curve of consumption against speed is ideally determined by measuring consumption at a series of steady speeds, using the minimum throttle opening required to maintain each steady speed on a horizontal road without significant bends and in still air. Engine, transmission, wheel bearings, etc., should be at equilibrium temperature, and corrections should be made for any significant departure from standard atmospheric conditions. These ideal requirements, however, can rarely be approached. In practice, an approximation satisfactory for most purposes can be achieved by taking measurements on a closed near-horizontal circuit, such as the MIRA high-speed track, when wind is light.

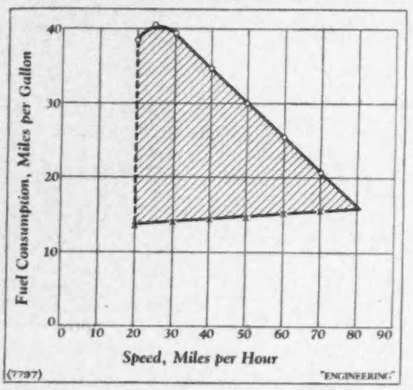
The lower curve of consumption against speed shows the fuel consumed at full throttle at each of a series of steady speeds, and may be obtained either by holding the car at each speed by its own brakes or a dynamometer trailer, or by computation from data derived in full-throttle consumption bench tests on the engine and measurements relating engine speed to vehicle road speed.

As the diagram shows, a very wide band exists over a substantial part of the speed range, and this illustrates the difficulty of quoting an average fuel consumption for a vehicle. Nevertheless, some such information is frequently and understandably desired, particularly by the prospective car owner. To present a reasonably complete picture, therefore, some such procedure as that now adopted by MIRA is desirable. Briefly, this measures fuel consumption under the following conditions: minimum throttle at steady speeds over a complete lap of the high-speed circuit; at the same series of speeds but at full throttle with brake application (over shorter distances, average of three readings taken); and on a selected public road route, including towns with heavy traffic, hills, busy main roads, and less-frequented country roads.

TOP SPEED

There is frequently a variation, outside the limit of accuracy of speedometers, in the top speed of a car as quoted by different observers. This is because of such environmental factors as atmospheric temperature, pressure and humidity, wind speed, and the type of road surface. There are also few stretches of roadway or test track long enough for the engine and transmission to reach equilibrium conditions at full throttle.

However, a maximum-speed figure is often required, particularly in relation to forecasts of it based on power available and power required to overcome rolling and wind resistance. A reasonable way of measuring top speed for development requirements of this sort, and a means of comparing different cars, is to run the car at full throttle several times around a closed-circuit high-speed track and then time complete laps. This method does allow the achievement of equilibrium conditions and, provided wind speed is low, largely eliminates wind effects. Such tracks do, however, incorporate super-elevated bends and these increase rolling resistance compared with straight-line driving. The general effect seems to be that top speeds measured on high speed tracks are usually higher for low-speed vehicles and lower for high-speed vehicles than the speeds measured on straight roads.



Fuel consumption can vary over a band of values at a given speed. The specification of the maximum and minimum fuel consumption gives a more realistic assessment than a single "average" figure.

RIDE

The ride quality of a vehicle—a vital characteristic of car performance—is still in the main assessed by the subjective impressions of drivers and passengers. The difficulty of applying objective methods arises from the physiological complexities of human beings, the variations in their requirements, the conflict between short-term comfort and long-term fatigue effects, and factors other than the actual physical movement of passengers—environmental noise, eye activity, preoccupation of the mind, etc.

While the ideal would be complete freedom from enforced, as distinct from voluntary, movement, such as state cannot be obtained. The problem then arises as to what departures from this state are to be preferred. For example, while it seems likely that the amplitudes of movements in all directions should be as small as possible, it is not clear what the optimum frequency for such movement is. Short term comfort may be most satisfactorily obtained by low-frequency movement, but this may induce sickness in the long term. Conversely, high frequency movement, while uncomfortable to all but the young and sporty, is known in many cases to prevent long-term sickness.

In spite of such subjective aspects, there is an increasing need to know in detail what changes in ride occur with changes in design, particularly with regard to new suspension systems and media. Analogue computers may eventually deal with vehicle movements satisfactorily, but the ultimate requirement is to know what happens to a live person on the sprung seat of a car.

Subjective assessment is, therefore, now being supplemented by attempts to produce instruments which will record the accelerations fed into a human being through a car seat. Particularly important are the accelerations received by the head—the site of the organs of sense and balance.

First steps along the difficult paths of this investigation have been taken at MIRA. Recordings on magnetic tape, with subsequent analysis, have been made of the output of an accelerometer in the mouth of a passenger in a moving vehicle. The investigations, however, were not sufficiently far advanced for Dr. Fogg to discuss them in detail.

HANDLING

As with ride, the handling of a vehicle is still assessed ultimately on a subjective basis, although much quantitative data is available on some of the components influencing handling, such as tyres. The stage has not yet been reached where everyone is agreed in quantitative terms on precisely what is desirable in the manoeuvring of a vehicle.

Nevertheless, on certain limited aspects of handling—for instance, the relationship between steering wheel and vehicle movements under steady state conditions—measurements can be made which yield some basic data on the stability of vehicles on bends. The first requirement for such measurements is a steering pad. This is a horizontal disc of smooth concrete, marked with a number of concentric circles of radii up to 120 ft, with a centre siting post. The car is driven at a series of constant speeds around a number of the circles and instruments attached to it measure steering wheel angular movement, the angles through which the front and rear wheels move, and the roll and attitude angles of the car body. From such measurements and the behaviour of the vehicle when it finally "breaks away," basic stability information—such as understeer or oversteer related to radial acceleration, influence of roll on steering, etc.—can be determined.

Progress towards improved vehicles must involve wider application of methods of measurement and depend on the ability to make more exact comparisons. This requires the use of standard methods. Dr. Fogg pointed out that the performance of competitive vehicles from foreign countries cannot be ignored, and to obtain the maximum reliable information in Britain in the most economic manner required consistency in methods of measurement.

Magnetic Annealing of Soft Metal Alloys

One of the unsolved mysteries of metallurgy, that of magnetic annealing, is now coming closer to a solution as a result of research now being carried out at the Bell Telephone Laboratories in the United States. For many years it has been known that if soft magnetic alloys of nickel-iron (such as Permalloy) and nickel cobalt iron (such as Perminvar) are heat treated in strong magnetic field, their magnetic moments will tend to align to produce magnetically oriented material. This tendency arises from a uniaxial magnetic anisotropy introduced by the field heat treatment. The origin of this uniaxial anisotropy, however, has never been properly understood.

In addition to the goal of increased general understanding of anisotropy in magnetic metals, Bell Laboratories is interested in the problem because large quantities of alloys such as Permalloy are used in inductor cores for communication equipment.

Fine Permalloy tapes are needed for " Twistor" wire, which is used in various electronic memory devices. Also, it is possible that thin films of these alloys could be used in memory devices for digital computer circuits, since they can be switched from one polarisation direction to the opposite one, with an over-riding magnetic field. Switching times for such films could be as low as 10^{-9} seconds. They could also be used as non-destructive readout memory devices, by sensing the polarisation with a magnetic field which does not quite over-ride the built-in field.

The theoretical basis for magnetic field annealing has been debated for some time. The generally accepted theory is based on short range ordering of the metal atoms in the alloy. Recent work at Bell, however, indicates that magnetic polarisation does not result when these alloys are heat treated in a field, unless about 14 parts of oxygen per million are present in the alloy. With less than this oxygen content, the annealed alloys do not respond and no uniaxial anisotropy is developed.

At oxygen contents between 14 and 20 parts per million, there is apparently little variation in the strength of the anisotropy. Although there appears to be little appreciable change in the magnetic response for reasonable increases above this level, substantially greater amounts of oxygen may result in the formation of oxides of the constituent metals.

While the mechanism by which oxygen causes this effect is not yet fully understood, workers at the Bell Laboratories have proposed the following theory: the oxygen atoms deposit on the stacking plane of the crystal at certain elevated temperatures, resulting in a displacement or dislocation of the next plane of atoms. When enough of these oxygen atoms are present, the alloy can be magnetically oriented by field heat treatment.

Confirming this theory is complicated by the fact that it is almost impossible to point out the location of the oxygen atoms in the alloys by X-ray or neutron diffraction techniques, or even whether the alloy itself has segregated, because of the similarity between the atoms of cobalt, nickel and iron. Also, of course, the minute quantities of oxygen involved make the analytical process particularly difficult.

From a practical standpoint, it seems that more uniform magnetic materials can be produced by close control of the amount of oxygen present in the alloy. However, a great deal more study will be required before the theoretical basis for the phenomenon of magnetic annealing is understood in complete detail.

Magnetic Properties of Nickel Ferrite-Aluminates

Work has continued at the Radio Research Laboratory of the DSIR during the past year, on the measurement of the magnetic properties of a series of nickel ferrite-aluminates. This work, which includes measurements of the microwave tensor permeability components and the static magnetisation characteristics, is reported by the Director, Dr. R. L. Smith-Rose, in his annual report.

For the static magnetisation measurements the Sucksmith type of balance which was hitherto used has now been replaced by a commercial semi-microchemical balance, which is more stable and about fifty times more sensitive. Using this, measurements of magnetisation below saturation are being obtained in addition to the saturation values. These data are required to enable interpretation of the microwave permeability measurements to be made in terms of the internal static field in the specimen. At low fields this is very much smaller than the applied field, due to the large demagnetisation factor of the disc-shaped sample used. Values of the magnetisation for internal fields down to a few oersteds are made on thin bars $12 \times 0{\cdot}5 \times 0{\cdot}5$ mm, air cored coils being used to provide the necessary non-uniform fields.

The saturation magnetisation measurements on the nickel ferrite-aluminate series ($Ni\ Fe_{2-x}AlxO_3$, with x carying between zero and 0·9) show an approximately linear fall of magnetisation with increasing aluminium content, up to $x = 0{\cdot}65$, followed by an increasing magnetisation with further addition of aluminium. There is, however, no indication of a true zero of magnetisation, such as would be expected from an exact cancellation of opposing spins at the compensation point. The minimum magnetisation measured is 3 e.m.u. per gm, which is about 6 per cent of the value of pure nickel ferrite.

The microwave measurements comprise observations of the change in resonant frequency and Q factor of an X band cavity when a small disc-shaped sample of the ferrite is placed in it. Owing to the doubly refracting property of a magnetised ferrite, the cavity resonance curve is split into two resonances, but for low values of the applied static field the amount of splitting is small. To overcome the consequent difficulty of measuring the two overlapping resonances separately, an extra piece of low loss ferrite is inserted in the cavity. This acts as a mode splitter, giving two separate resonances, and the effect of the sample under test on each of these resonances is easy to measure. This technique has a further advantage, that standing-wave measurements to determine the coupling factor between the source and the cavity are no longer required. The small frequency changes involved in the measurements are now obtained with increased accuracy in terms of the setting of the micrometer-controlled probe intruding into the resonance cavity of the frequency stabilising system. This enables frequency changes of about 20 kc/s to be detected.

The microwave measurements made on the series of ferrite-aluminates show the usual large dispersion of the real part of the permeability components, with correspondingly large values of the loss for microwave fields circularly polarised in the appropriate sense. The characteristic " low field loss," i.e., a loss peak for small values of the static field, is also exhibited by those members of the series with the largest values of saturation magnetisation.

Magnetic Logical Elements in Control Schemes

A new range of contactless sensing and magnetic logical elements, which have been developed to work together and to be incorporated into control schemes, has been announced by the English Electric Company. The new range has been developed in recognition of the reliability that can now be expected of static switching devices and because arduous conditions are often imposed on contact making devices, giving rise to a deal of trouble.

The logical elements are in the form of mechanically coded standard packages, providing the " bricks " from which any control scheme may be built up. The element is presented in the form of a plug-in unit consisting of a red nylon frame moulded to form a handle to one end and having a 32-way plug and socket connection at the other.

Two printed circuit component boards, one for the input circuit components and the other for the magnetic circuit components, are fixed into this frame and electrical connections are taken to the plug. Each assembly is a complete logical element providing " and," " or, " not," " memory " and " time delay."

All the standard packages have the same physical dimensions and in each moulded handle there is a label symbolising the logical function. The packages are presented as plug-in assemblies and designed to slide into a specially developed steel receptacle which will hold a number of the elements side by side. Though light in weight, the packages appear to be quite robust.

For control scheme engineering, the circuit details in any given logic function are standard. The control scheme is arranged by the wiring to the plug sockets. Interconnection between elements is easily made and subsequent scheme modifications are possible without having to modify the circuit within the standard package.

Using a " trigger " characteristic, each element is bi-stable, (either on or off), there being no inbetween condition. No matter how many elements are connected together, there is no attenuation of signal due to voltage dependency.

The new contactless sensing devices that have been developed are known as pick-offs and include magnetic push buttons, magnetic limit switches, proximity limit switches, linear differential transformers, rotary switches and contactless tachogenerators.

The logical element is essentially a low powered unit, and so a simple output unit capable of switching 100 watts has been developed to satisfy a number of applications where contactor or solenoid switching is at present employed. For high power switching the range of static apparatus available includes magnetic power amplifiers, saturable reactors, silicon controlled rectifiers, ignitrons exitrons and mercury arc rectifiers.

Magnetic logical elements and pick-offs are finding a place in control gear for all types of material handling applications, including conveyor systems, machine tools, food and chemical processes, blast furnace hoists, and automatic starting and stopping in steam plant and in the iron and steel industry.

Equipping Man for a Flight to the Moon

That man will one day reach the moon is now taken for granted. But much work has yet to be done in the new field of environmental systems engineering if he is to have any guarantee of a safe journey.

MAN's flight to the moon is perfectly feasible in the light of existing scientific knowledge. However, before this feasibility can become a reality, fresh engineering skills will be required in order to develop, design and make the equipment that will sustain him away from the only environment that he has known for thousands of years.

In the United States much money has already been spent, and vast sums are scheduled for future programmes that are, either directly or indirectly, aimed toward interplanetary flight. It can also be assumed that the Russians have similar, if not more advanced, programmes in hand. In fact, it is the competition between these two great rivals which is forcing the pace that will inevitably lead to man's lunar flight; because the only barrier now left between man and the moon is one which money and engineering effort will surely overcome.

The United States "space programme" for the next decade is an exciting one, beginning with the already established Project Mercury, and culminating in a manned lunar landing in 1970. Comments on this programme were made by Dr. E. W. Still in a paper entitled "High Altitude Chambers and Pressure Suits" read before the British Interplanetary Society on 28 April. Dr. Still, who is assistant managing director of Normalair Limited, Yeovil, gave a résumé of the American programme, as he sees it, and then went on to discuss the environmental requirements for interplanetary travel, and the engineering techniques being developed to meet them.

PROJECT MERCURY

Project Mercury, as Dr. Still pointed out, is under way at the moment and is scheduled to reach its climax at the end of next year by putting a man into orbit around the Earth. The vehicle to be used for it is to be of the smallest possible size consistent with the object of the exercise and will be launched by an Atlas rocket. A diagram of the manned Mercury capsule is given in Fig. 2, indicating the economic use of the space available.

The immediate programme is to fire three of these capsules in non-orbital trajectories about 100 miles high, landing in the Atlantic. The first will be empty, the second will contain a chimpanzee, and the third a man. This programme is scheduled to use Jupiter and Redstone rockets.

A monkey has already been taken to a height of 55 miles in a simulated Mercury capsule launched by a cluster of rockets, thus proving the basic soundness of the re-entry design, parachute system and recovery organisation. When the three sub-orbital flights are over, the programme will be repeated and then, if successful, it will lead to the orbital launching of a vehicle containing one of the seven astronauts now undergoing training in the United States.

The Mercury capsule, of which 20 are now being made by the McDonnell Aircraft Corporation, weighs about a ton. It is a truncated cone with a spherical cap as a floor and a small cylinder at the top containing the main parachute. Mounted above this is an important device: the escape rocket. This enables the astronaut to blow himself free from the parent rocket and to descend by parachute in the capsule, at any altitude between ground level (at take-off) and 100,000 ft. If the escape rocket and tower have not been needed by the time this latter altitude is reached, these components are blown free to save carrying them as excess weight up to orbital height.

A pressure suit will be worn by the occupant, who will lie on his back on a special couch moulded to his individual shape, providing a good support for his body during the high "g" periods of take-off and re-entry. These accelerative and decelerative forces will both be met in the same position, the attitude of the capsule being altered by small rockets during the first stages of re-entry to ensure that the curved floor of the vehicle (which has to bear the brunt of the violent kinetic heating) is facing into the air stream. Maximum forces of 8 or 9g are expected after take-off and during re-entry, if all goes well. Values up to 20g might have to be sustained for about 8 sec if the capsule re-entry trajectory were to be too steep; however, it has been shown that a subject using the special supporting couch can endure even this enormous force without permanent injury.

The present proposal for dissipating the very great quantity of heat generated during re-entry —the critical phase of which lasts for about five minutes—is to use an ablation shield on the outer surface of the curved floor of the capsule; that is, a layer of laminated glass-resin is allowed to become so hot that it vaporises and absorbs most of the heat that cannot be radiated. This has already been tried with a prototype mercury capsule and the temperature inside rose to 150° F for less than a minute, in spite of the fact that the re-entry trajectory was steeper than had been planned. Thus both the heating and deceleration problems seem to be well in hand as far as Project Mercury is concerned.

The maximum time in orbit would probably be only a few hours, enabling three or four circuits of the Earth to be made before descending somewhere in the Atlantic, as close to a predetermined location as possible.

The environmental control display indicates cabin temperature and pressure, and the partial pressures of oxygen and carbon dioxide. The environmental control system comprises two loops: the cabin circuit and the suit circuit. The former is responsible for cabin cooling and maintaining a suitable pressure, while the latter cools the suit, removes odours, carbon dioxide and water vapour and replenishes the oxygen. The pilot breathes pure oxygen at a pressure of 5 lb per sq. in and his suit is only inflated if the cabin atmosphere drops below that level. Activated charcoal removes odours, while lithium hydroxide is used for reducing the carbon dioxide concentration. Water vapour is condensed out in a heat exchanger and trapped in a vinyl sponge, which is periodically squeezed into a condensate container.

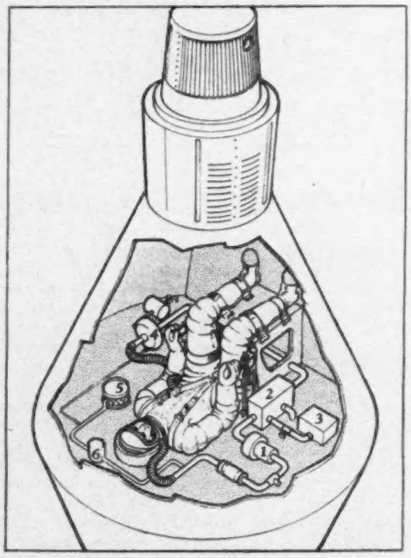


Fig. 2 The final stage of the Project Mercury will be to launch a manned capsule into orbit around the Earth.

(1) Compressor
(2) Evaporator
(3) Water tank
(4) Water absorber
(5) Liquid oxygen
(6) Demand oxygen regulator

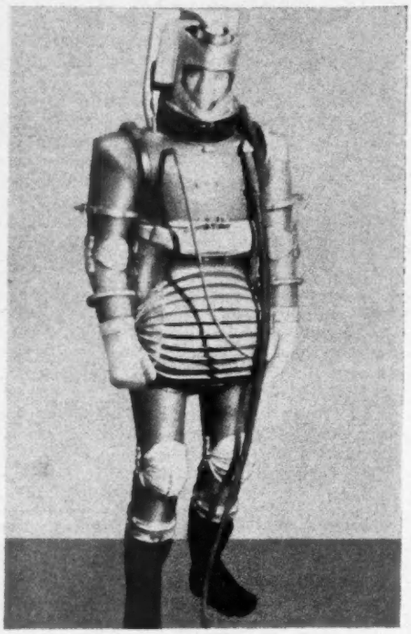


Fig. 1 Early experimental pressure suit, made by Normalair Limited, which may form the basis of a moon exploration suit. It affords positive protection from punctures and would provide an ideal foundation for a system of heat insulation.

It is quite obvious that, in addition to questions of temperature and pressure, environmental engineering is very much concerned with the biological necessities of man. This means that environmental engineers must have full knowledge of man's basic requirements in terms of oxygen, water and food intake, disposal of body wastes, and many other biological functions. In giving his paper before the British Interplanetary Society, Dr. Still dealt with these matters at some length before going on to describe the engineering systems that are being developed for orbital and lunar journeys.

The environmental conditioning of a re-entry vehicle falls naturally into two parts: the provision of a suitable atmosphere, and the cooling of the cabin. Since the trip is of relatively short duration it has been decided to use liquid oxygen in a converter system and to remove carbon dioxide by absorption with lithium hydroxide.

There are several facets to the cooling problem; the metabolic heat load of the crew, the load developed by the electrical equipment and the re-entry case, which also demands special attention.

Since the re-entry vehicle will have to endure very severe kinetic heating during the re-entry phase, effective insulation is provided all over the cabin surface and it is estimated that, by using modern super-insulants, the heat flux into the cabin during re-entry can be kept to a figure comparable with the internal loads. On the other hand, it is not possible during re-entry itself to dissipate an internal load by

radiation since the skin temperature is far too high. Fig. 3 is a graph that was used by Dr. Still to illustrate the "flight corridor," along which a re-entry vehicle would proably return to Earth. Also shown on this graph are lines indicating the temperatures and decelerations experienced by a small ballistic vehicle during re-entry.

While a winged re-entry vehicle may be expected to experience a smaller maximum deceleration and peak temperature, it will spend a longer time at high temperature. Consequently, almost perfect insulation seems to be the best approach to the problem, coupled with one of two possibilities: the first being to precool the interior of the vehicle to a suitable level before re-entry so that the ensuing temperature rise is not unbearable to the crew, and the second to use a liquid such as water, the boiling of which at reduced pressure would absorb the internal heat load during re-entry.

The latter idea is attractive and it has been calculated that the evaporation of 30 to 50 lb of water, at a temperature compatible with the crew's comfort, would be sufficient to dissipate the internal load during re-entry. However, since the water is ejected overboard in the process, it can only be used once.

Similarly, it is possible to dissipate the internal load during orbiting conditions by simple radiation from the skin of the vehicle, without first raising the temperature level at which the heat is rejected. However, for this particular vehicle it has been thought useful to include a light freon-cooling system which has various advantages for the different flight phases.

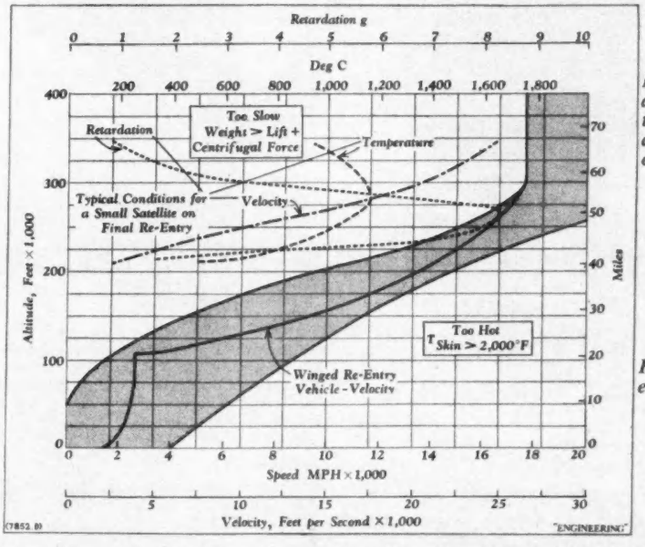


Fig. 3 (left) Altitude against speed, depicting the "flight corridor" along which a winged re-entry vehicle would probably return to Earth.

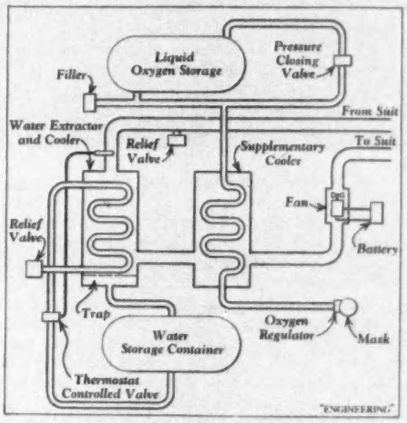


Fig. 4 (right) A water evaporation system for a lunar suit.

Firstly, it can be used to condense out exactly the amount of water vapour which is rejected by the crew, at a temperature well above the freezing point of water. This process ensures that no icing-up occurs in the water condenser which might otherwise be the case if direct cooling of the cabin air were used. Secondly, the total radiating area necessary in normal flight conditions can be reduced a little by rejecting the cabin heat at a higher temperature, though this saving is not large. Thirdly, by running the freon system at a higher power rating for short periods, either normal cooling can be achieved when the condenser area is effectively reduced (for example, by solar radiation due to incorrect orientation) or the cabin temperature can be reduced prior to re-entry. A drop of approximately 25° F before re-entry is sufficient to keep the final temperature after re-entry to about 95° F. Finally, the control of cabin temperature is possible by varying the power supplied to the freon compressor.

A full pressure suit will be required by man when landing on the moon in order that he may leave his spacecraft and carry out scientific observations. This garment must provide him with a self-contained environment and must present a minimum impedance to the man's mobility as a scientific observer.

THE LUNAR SUIT

Although the lunar day is equivalent to 14 Earth days, the time spent away from the craft would be dictated by Earth habits. A six-hour period could probably be contemplated as the time that a man could work without a prolonged period of rest or an intake of solid food. Such a period forms the basis of calculations concerning the lunar suit.

A man working or walking on the surface of the moon could be expected to consume about 0·3 lb of oxygen per hour and generate energy equal to about 16,000 Btu an hour. In addition, he would reject some 0·375 lb of carbon dioxide per hour and give out about a pound of water. Although the maximum Moon day temperature would be between 250 and 300° F, and the maximum night temperature would be about −240° F, the suit must be capable of maintaining the man's skin temperature at about 91° F. Normal methods of heat exchange are lost as soon as enclosed in such a garment. To cater for all conditions, therefore, a circulation of gas over the body must be maintained so that all the heat and water vapour given out can be carried away to be rejected elsewhere.

In connection with the equipment required for the suit there are two basic problems to be faced: one is the removal of heat from the garment and the other is the provision of a breathable atmosphere. It is possible to treat these cases separately, or jointly, and to design a garment accordingly.

As it is possible to supply the environmental conditioning of a suit by several different methods, Dr. Still described in detail only the two that he thought were the most attractive. The first he called a "liquid oxygen evaporation system" and the second he described as a "water evaporation system." It is thought that the latter is the most likely to be used since it is lighter. A diagram showing its working principles is given in Fig. 4.

In this arrangement the cooling is achieved by using water as the medium to be evaporated. Water has a heat extraction potential of 1,030 Btu per lb, compared with liquid oxygen at only 154 Btu per lb, if expanded to vacuum conditions. Unfortunately, it is unable to provide motive power for circulating the ventilating gas or maintaining carbon dioxide at a low level. It is accordingly necessary to make a separate provision for removal of carbon dioxide.

At the absolute pressure of this garment, the amount of oxygen likely to be inspired directly from an oxygen supply is unlikely to exceed 8½ lb for the six-hour period, even if a high work rate is maintained. This compares with an actual consumption of about 2 lb of oxygen and an output of some 2½ lb of carbon dioxide for this period, the latter requiring 3½ lb of anhydrous lithium hydroxide to remove it.

Bearing in mind that the presence of a lithium hydroxide absorption bed would increase the power for circulation and would contribute some heat output because of the chemical reaction, it is felt that the slight advantage in weight achieved by using lithium hydroxide may not be worthwhile. It is therefore possible to choose a system in which oxygen is breathed directly from the storage supply, since this is simpler than adopting a recirculated breathing system. This choice would not necessarily be possible at higher suit pressures because the oxygen consumption would then increase noticeably.

Consequently, in the system proposed the cooling would be achieved by controlling the flow of water from the storage container through a heat exchanger coil to the moon's atmosphere, which is a near vacuum. A relief valve would be desirable to prevent the water freezing in the heat exchanger coil as a result of the evaporation, at the expense of its own sensible heat.

Water would be condensed in such a system, and could be used as a source of cooling by being transferred to the storage container. As the container would be pressurised from the ventilating circuit, such a transfer of condensate would be relatively straightforward and automatic with the displacement of the liquid in the container. If used as a subsequent means of the 0·6 lb of liquid condensed in the tank would, therefore, require only about 3 lb of liquid in the first instance. Low work rate levels result in lower water outputs, but, equally, low heat outputs. The oxygen used for breathing purposes would also provide some supplementary cooling, though it is considered advisable to look upon this only as a useful bonus.

Circulation of the ventilating gas would be done by an electrically-driven fan, using a battery. A suitable fan and motor would weigh about 4 lb and work at around 20 watts. The battery would also weigh about 4 lb. Analysing the weight of the system, it would appear that the total need not be more than 40 lb (and it would be less bulky than the liquid oxygen evaporation system). Of this 40 lb, some 12 lb would be consumable.

In concluding his lecture, and in dealing with the more far distant problems of interplanetary travel, Dr. Still said, "It is thus possible to conclude that although the application of existing knowledge should enable a man to live during all stages of a journey to the moon, as well as on the moon itself, the indications are that for journeys to other planets such as Mars or Venus, which are at present estimated to take several years, a modified closed-circuit ecology using algae will probably be necessary."

Always Summer

AT FIRST sight it may look no more than an ordinary greenhouse, though perhaps rather a nice one and carrying a very good crop. Closer inspection would reveal that it is a mass of electronics and automatic controls.

In fact, it is the automatic "Greenhouse of Tomorrow" that was being shown at the Floralia at Ghent. It was planned by the horticultural section of the Electricity Council and constructed in conjunction with the British Electrical and Allied Manufacturers Association. The object was to provide under fully automatic control three separate climates and two seasons simultaneously in one house. This is done by means of controlled lighting, heating, and watering.

The house itself is an aluminium framed structure 28 ft long by 10 ft 6 in wide. The layout follows the traditional pattern of a bench on the south side and an open border on the north. Space heating is provided by four banks of three tubular heaters loaded at 60W per ft run. Control is by a thermostat with the unusual provision of an automatic change of temperature to simulate day and night. This is done by a small motor that moves the setting over a range of 10° F so that maximum is reached at noon and minimum at midnight.

Ventilation is by a 12 in extractor fan with automatic louvres and controlled by another thermostat. Protection against pests and diseases is given by an electrically heated unit that discharges insecticides or fungicides as smokes or aerosols into the atmosphere.

For the exhibition, the bench was laid out for propagating with a 4 in bed of sand warmed by mains cables rated at 15W per sq. ft to give a root temperature of 75° F. One half of the bench is subjected to mist propagation, in which the cuttings are kept covered with a film of water from an intermittent spray controlled from a sensing element. An additional control reduces the amount of spray progressively to "wean" the cuttings for planting out.

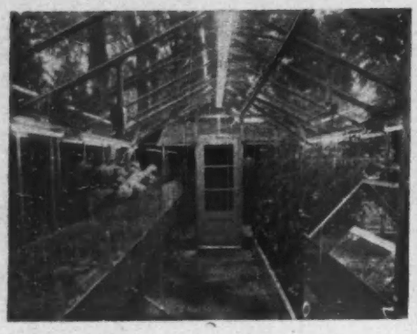
The other half is watered from an Alkathene pipe laid between the rows of plants with holes at intervals. Again there is a sensing element consisting of a porous block with opposed electrodes. When the block dries out the circuit is broken and watering occurs. The duration of the application is governed by a drip feed into a small container fitted with an automatic siphon. When the water siphons over, it flows on to the block, restoring the circuit and stopping the spray. Root warming mains cables are loaded to 7½W per sq. ft.

In the enclosed propagating case the root and air heating is provided by separate runs of mains cables, those for the air being thermostatically controlled and those for the roots by hand switching and an inserted thermometer. The temperature is kept about 15° F above that of the rest of the house.

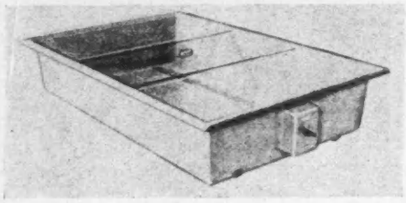
Within the house is also a growing cabinet with the environment completely controlled. It measures 8 ft long by 2 ft 9 in wide by 3 ft high. Space heating is by electric cables run on a false floor grid about 6 in above ground level. An inlet fan blows air through the false floor and out of louvres at the top. Both fan and heating are thermostatically controlled. Lighting is provided by four 8 ft 200W warm white fluorescent lamps with provision for the insertion of one or two tungsten lamps to improve the red component. The period of lighting is controlled by a solar type switch. Thus it is possible to simulate any season of the year.

Supplementary light is provided for the whole greenhouse by four rows of 8 ft 200W warm white tubes controlled through a photoelectric cell so that they are switched on when the natural light falls below 3 lumens per sq. ft. A solar type switch is used to contain this artificial lighting within the natural day length.

One half of the open border (the heating for which is controlled by hand switching, 12 hours on and 12 off) is arranged for the all-the-year flowering of crysanthemums. Suspended over it are tungsten lamps, controlled by a time switch, and black cloth covers which are used together to provide day length control. Provision is also made for giving supplementary light to a restricted number of plants by suspending a 400W MBFR/U lamp over one end of the propagating bench. This lamp is also time-switch controlled.



Three separate climates and two seasons of the year are provided in the automatic greenhouse.



Three seed boxes can be placed in this heated propagating tray.

In addition to the greenhouse, the exhibit included three 5 ft square frames of more conventional design. One was for salad crops with soil warming at 7½W per sq. ft from a low voltage supply; the second was for propagating with mains heating of both soil and air, and the third had only frost protection from thermostatically controlled mains cables.

Automatic greenhouses are large, and even automatic frames can be quite costly. But for those who want some form of heating for propagating, there is the tray shown in the third illustration. It measures 30 in by 18 in by 5 in and will take three standard 18 in by 10 in seed boxes. It is made of glass fibre and heat is supplied by a mat bonded into the base. The rating is 50W at 250V and control is by a thermostat. The range of temperature settings is from 60 to 145° F. The box is covered by three strips of glass (the centre one being free to slide) and the seed boxes are supported 1 in above the bottom. It is made by Marketad Limited of Shoreham Airport, Sussex.

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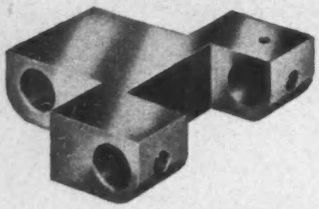

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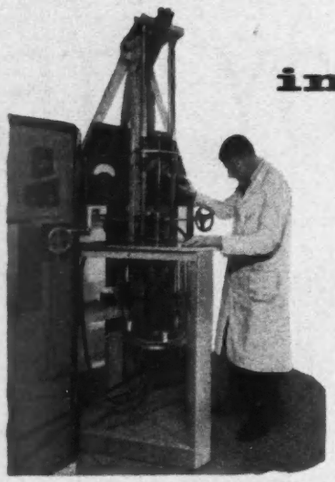

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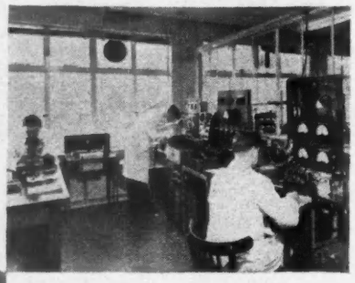

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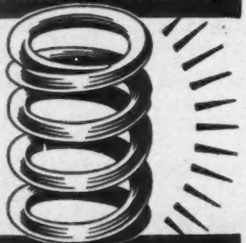

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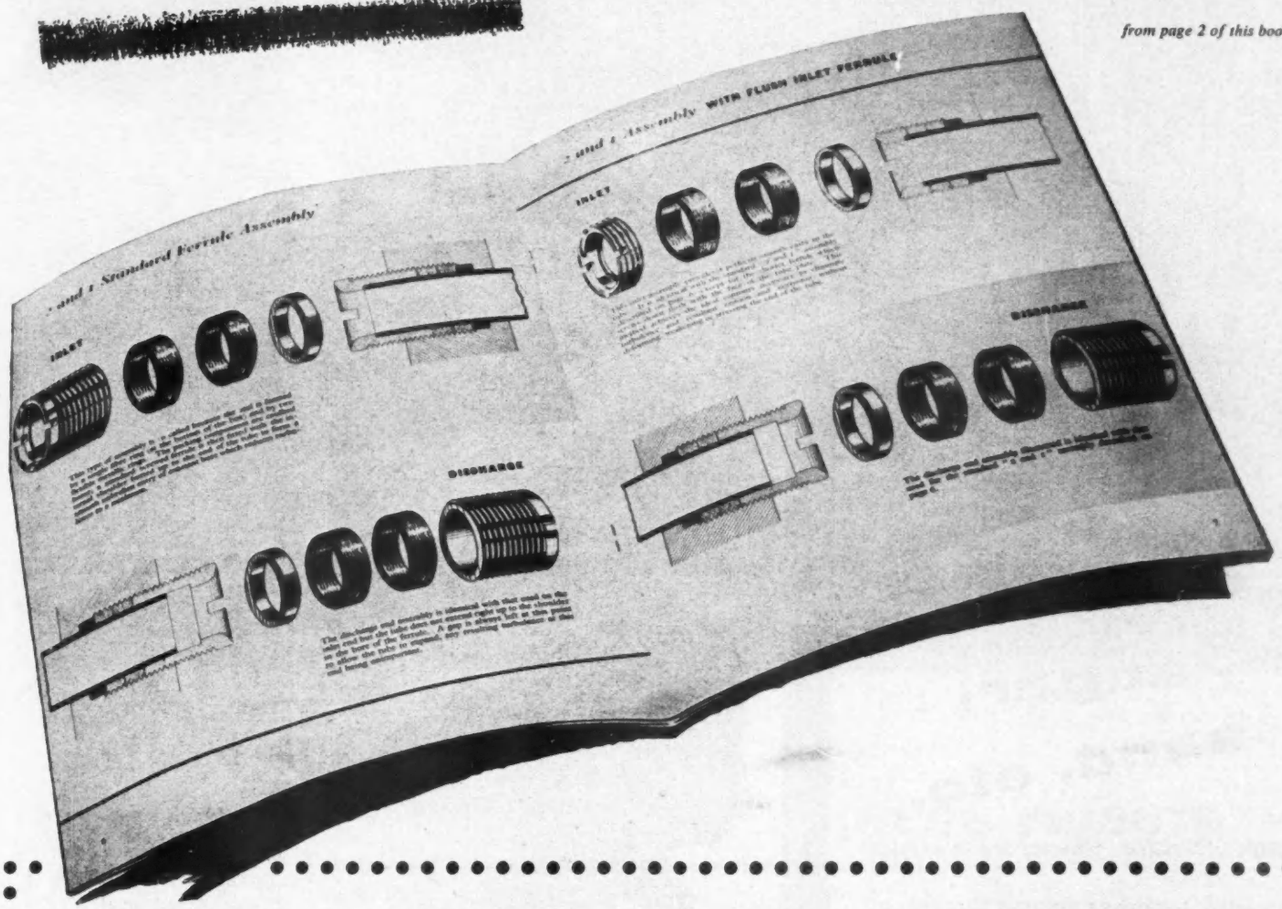

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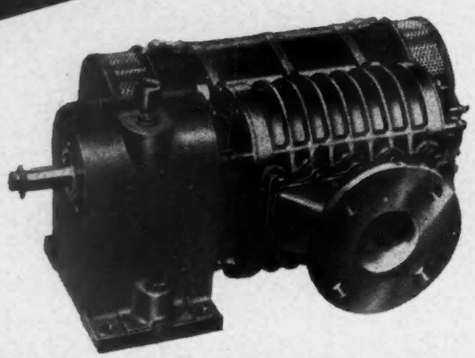

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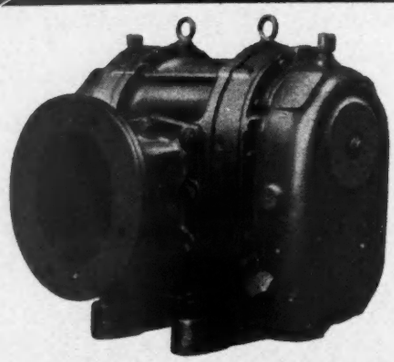

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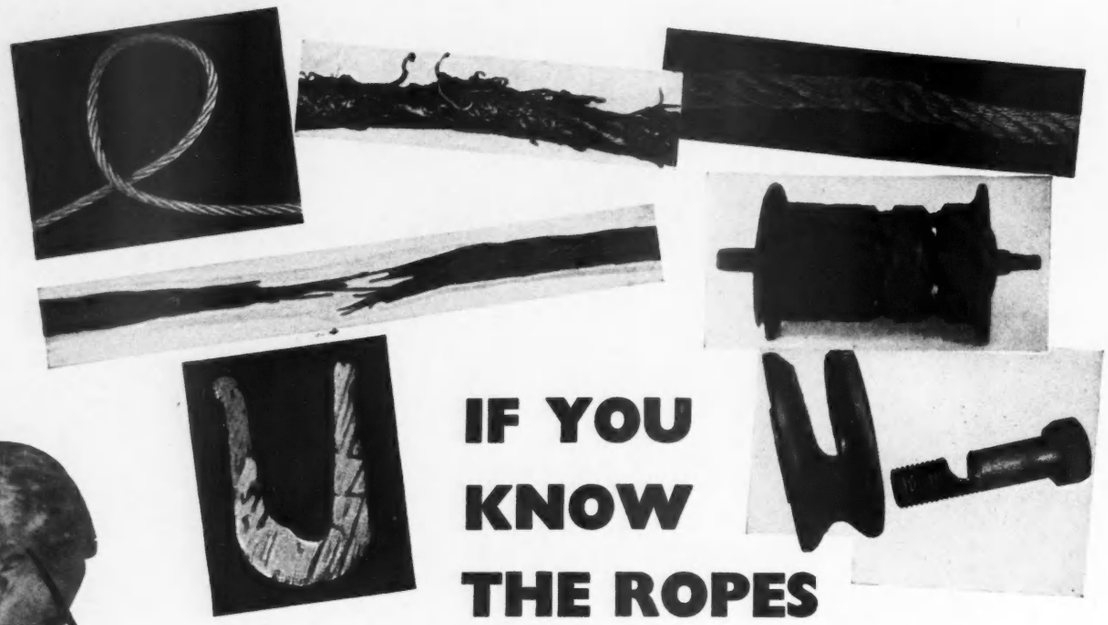

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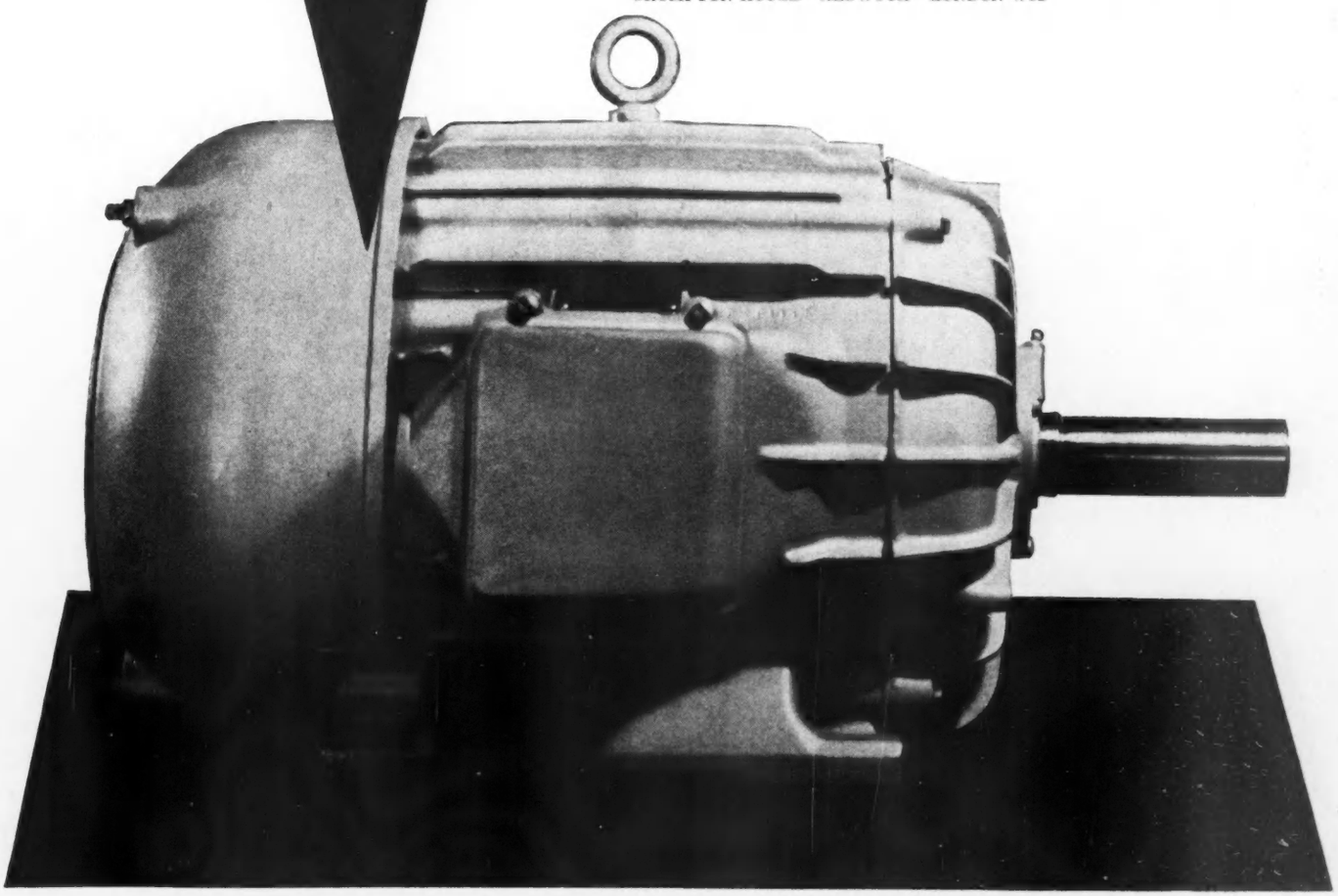

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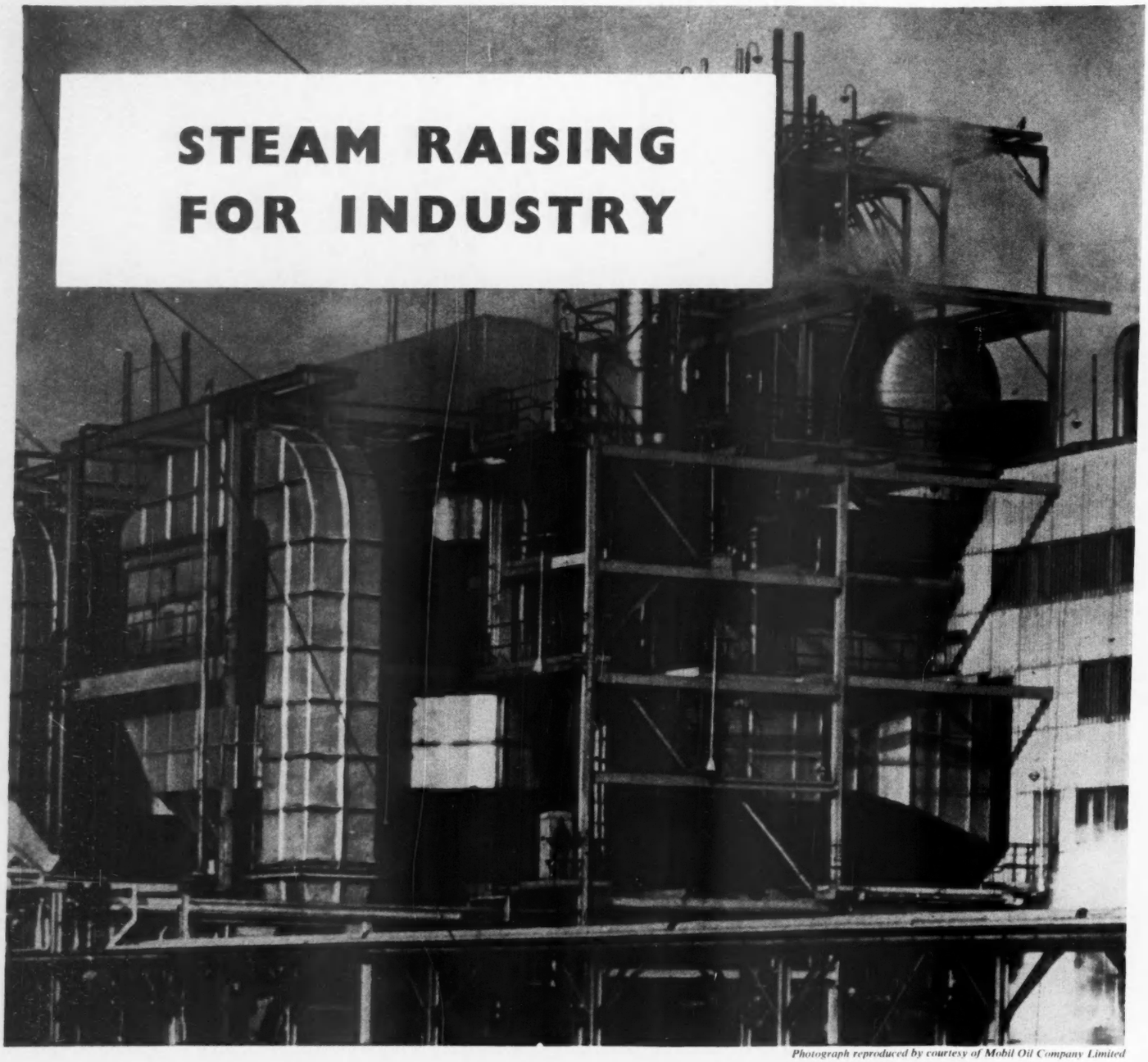

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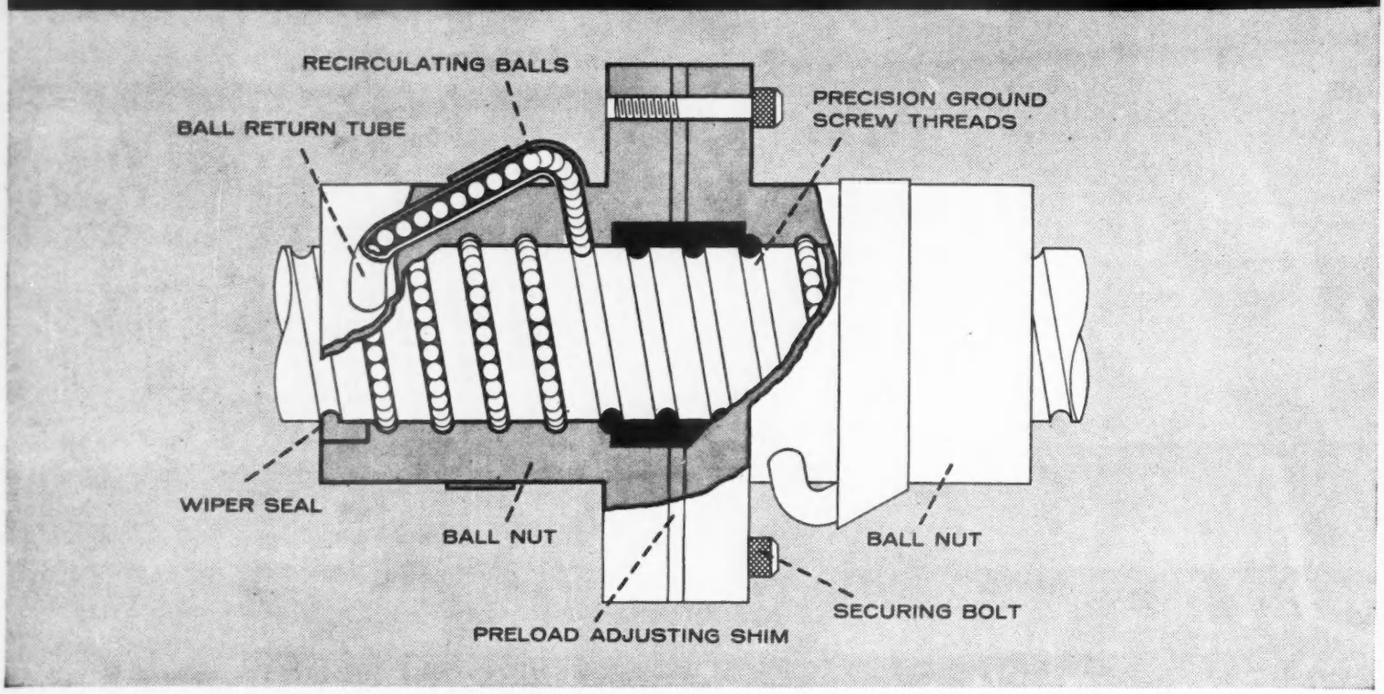

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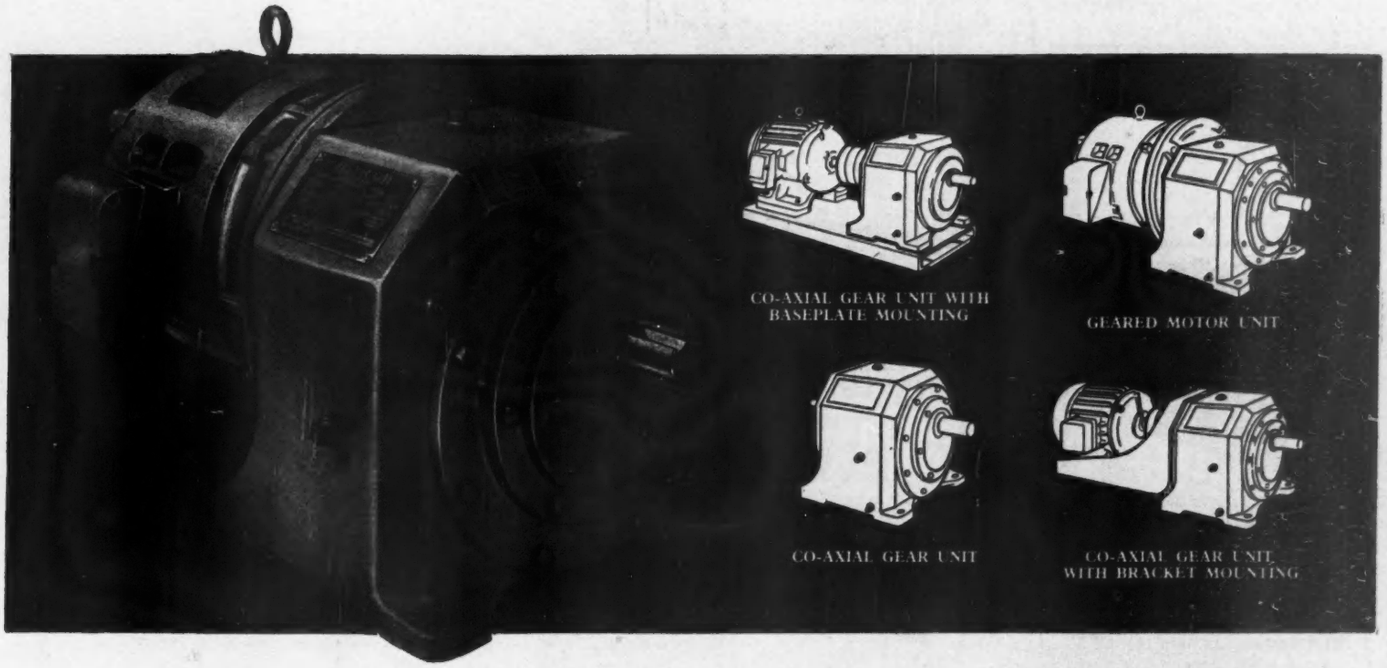
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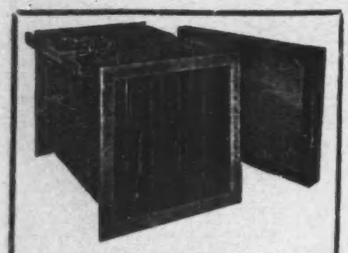

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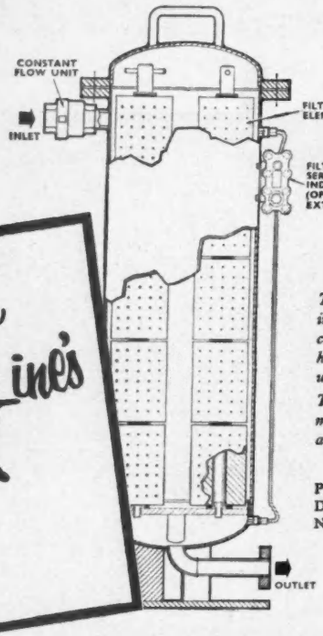

The Micro-Pak is available in a range of capacities, with centre-bolt or multi-bolt head, and either heated or unheated.

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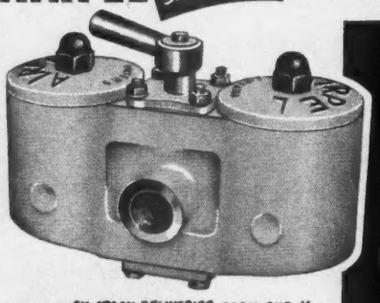

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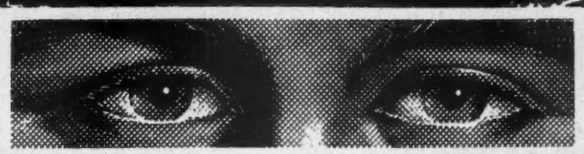

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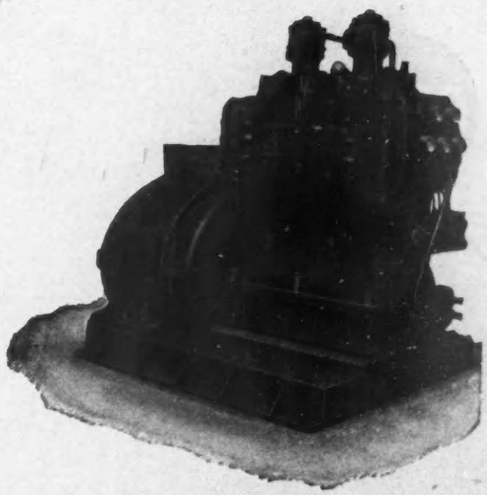

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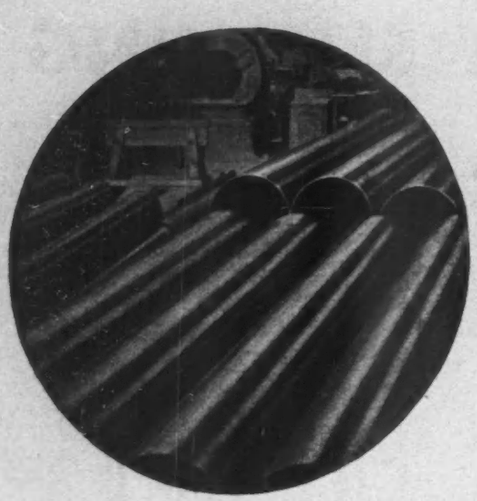

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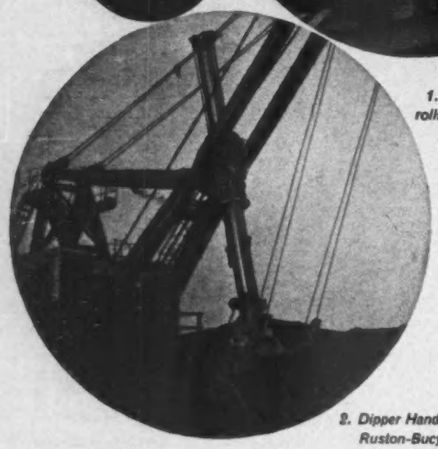

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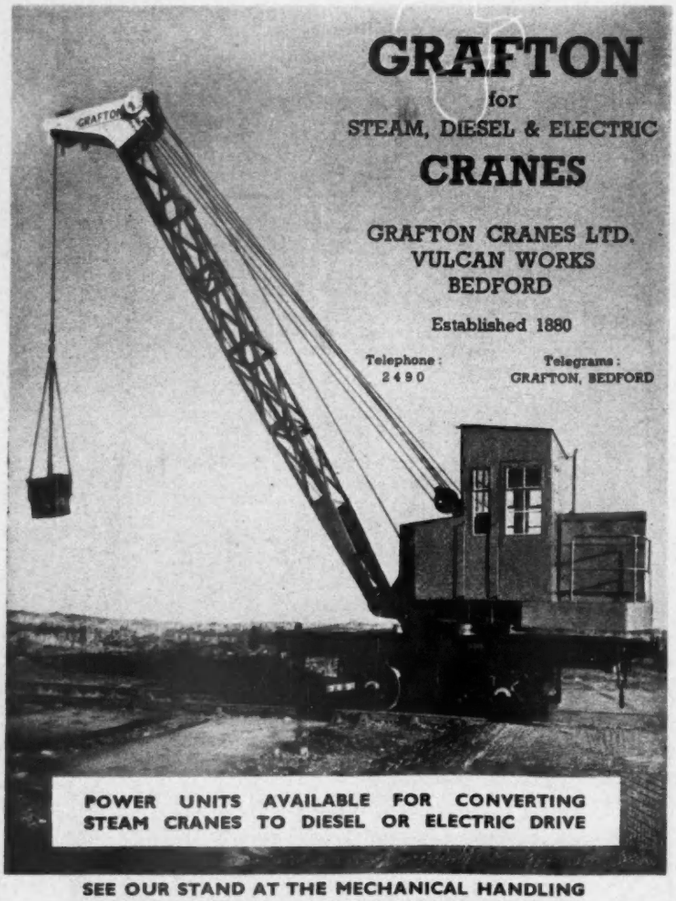

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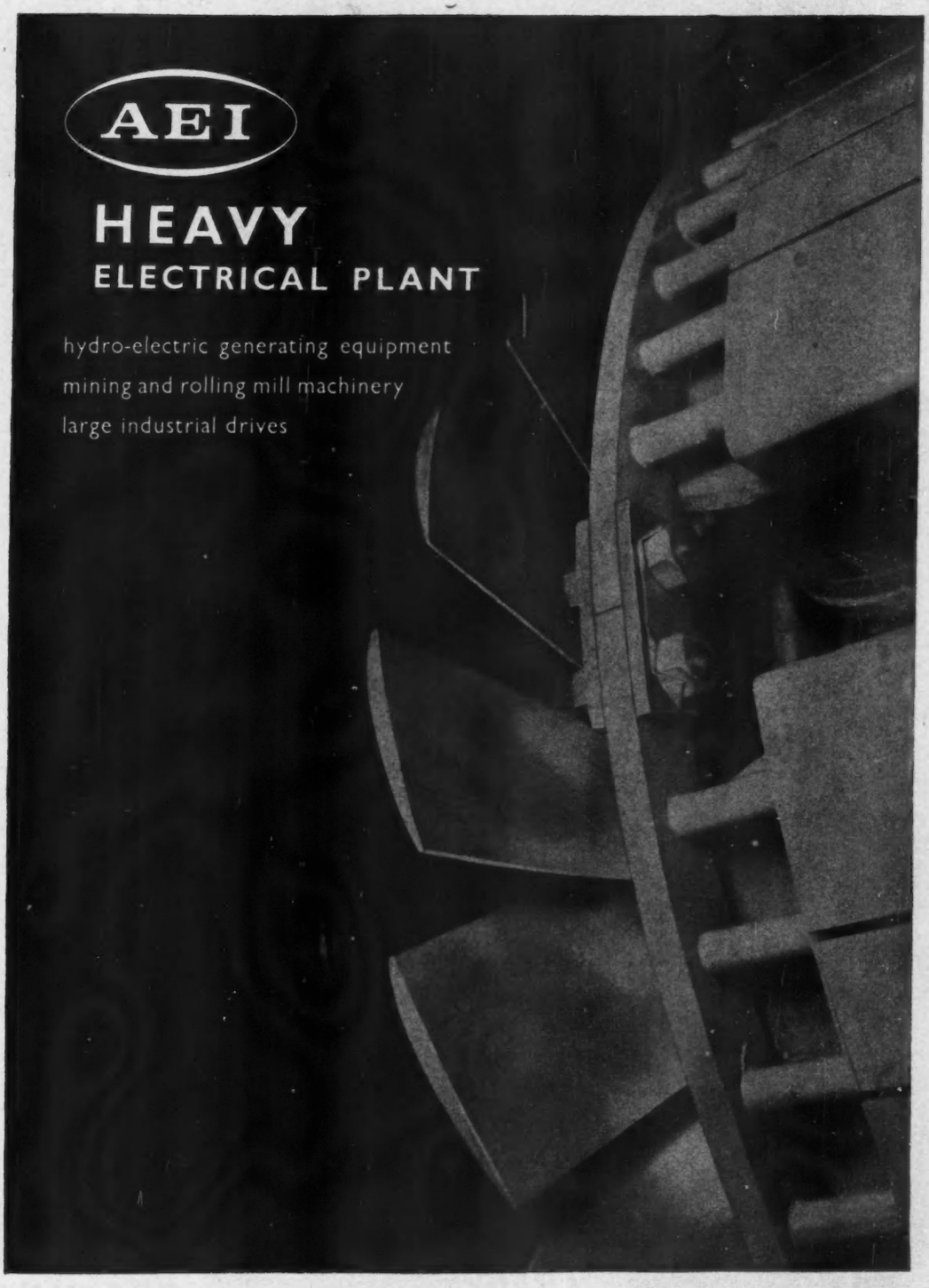

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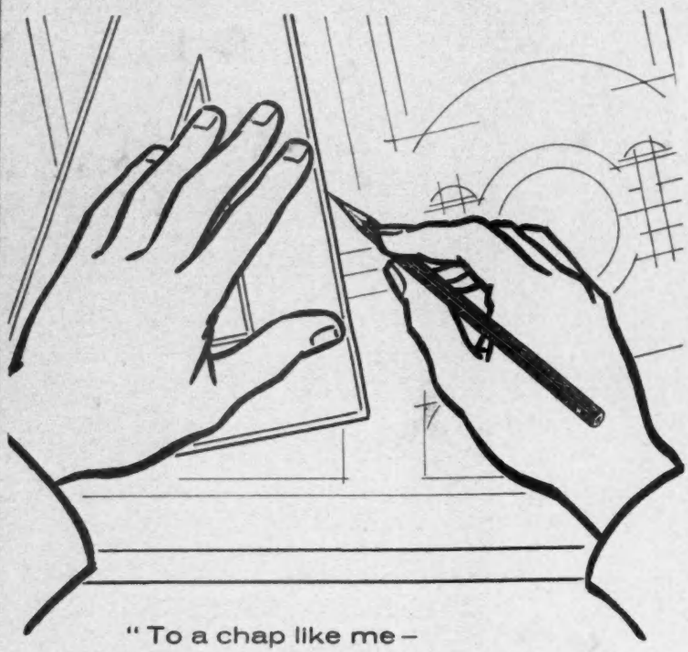

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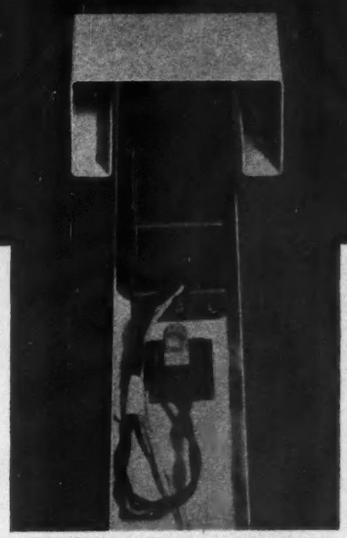

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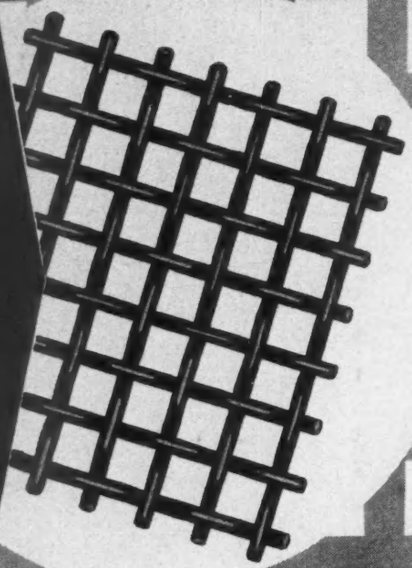

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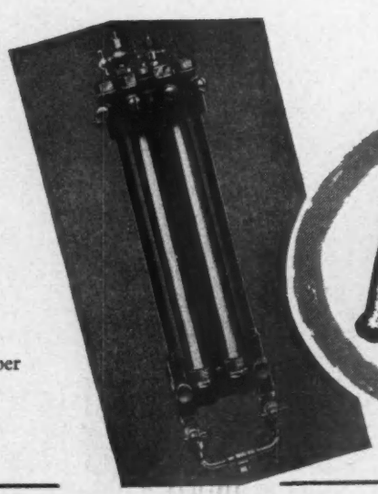

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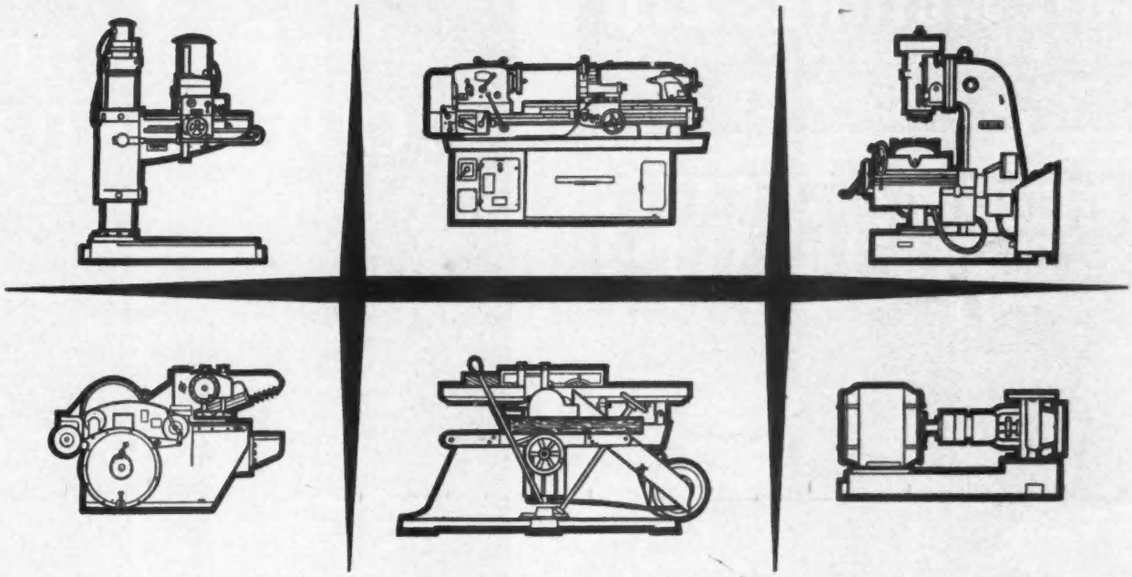

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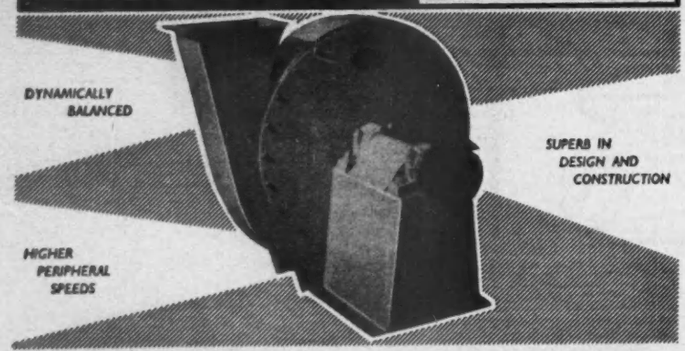

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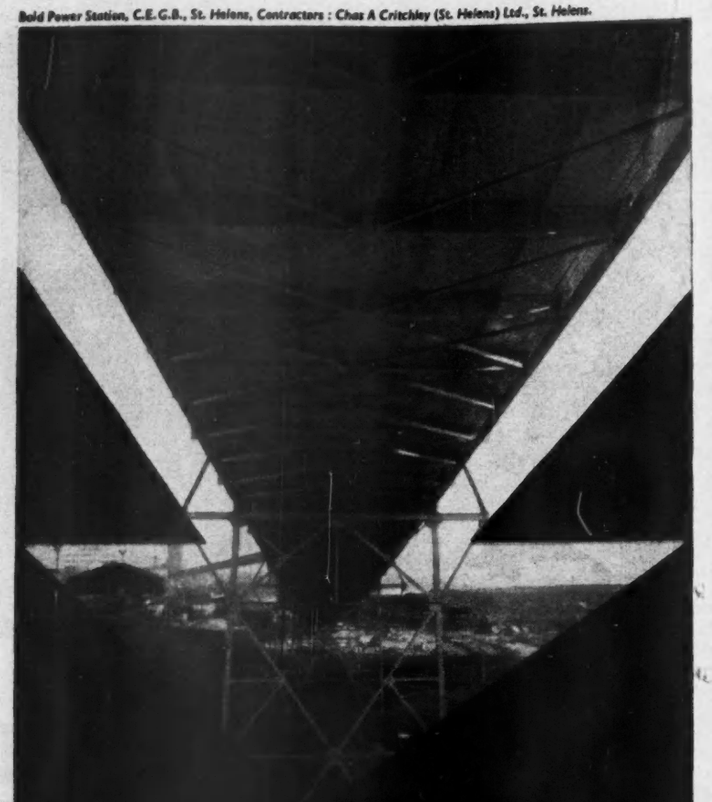

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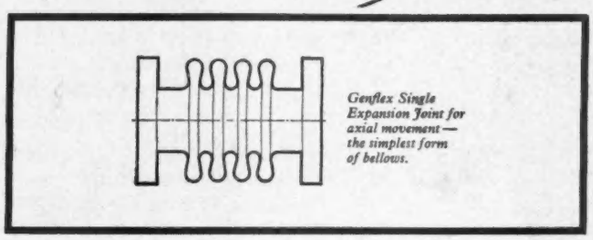

Genflex Single Expansion Joint for axial movement — the simplest form of bellows.

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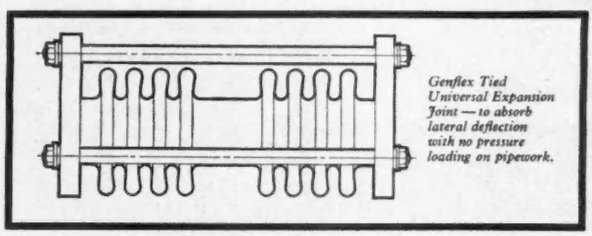
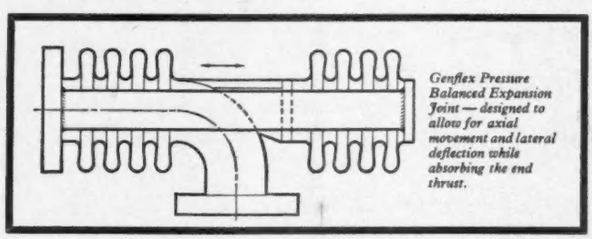
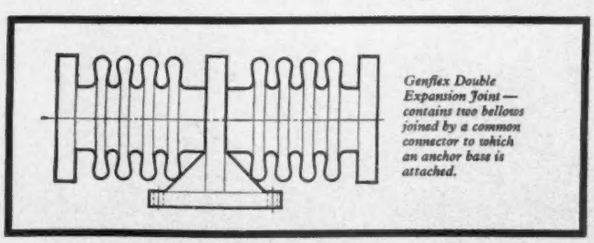


Genflex Tied Universal Expansion Joint — to absorb lateral deflection with no pressure loading on pipework.



Genflex Pressure Balanced Expansion Joint — designed to allow for axial movement and lateral deflection while absorbing the end thrust.



Genflex Double Expansion Joint — contains two bellows joined by a common connector to which an anchor base is attached.

The illustrations above show just a few of the many types of Genflex expansion joints produced to accommodate various pipe movements.

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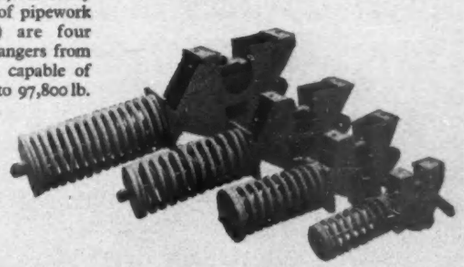

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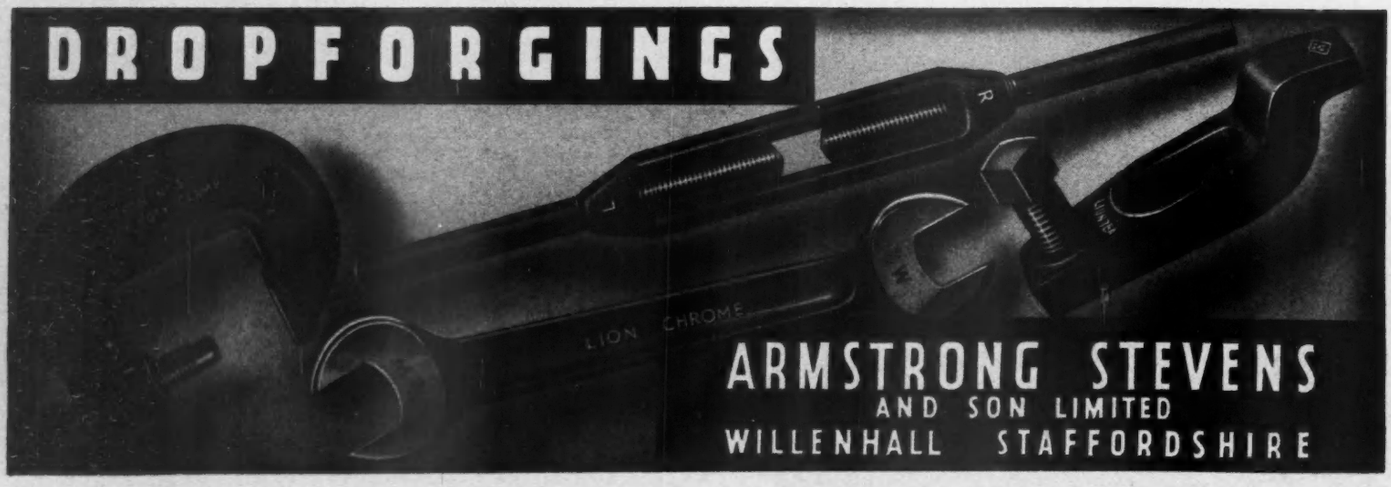

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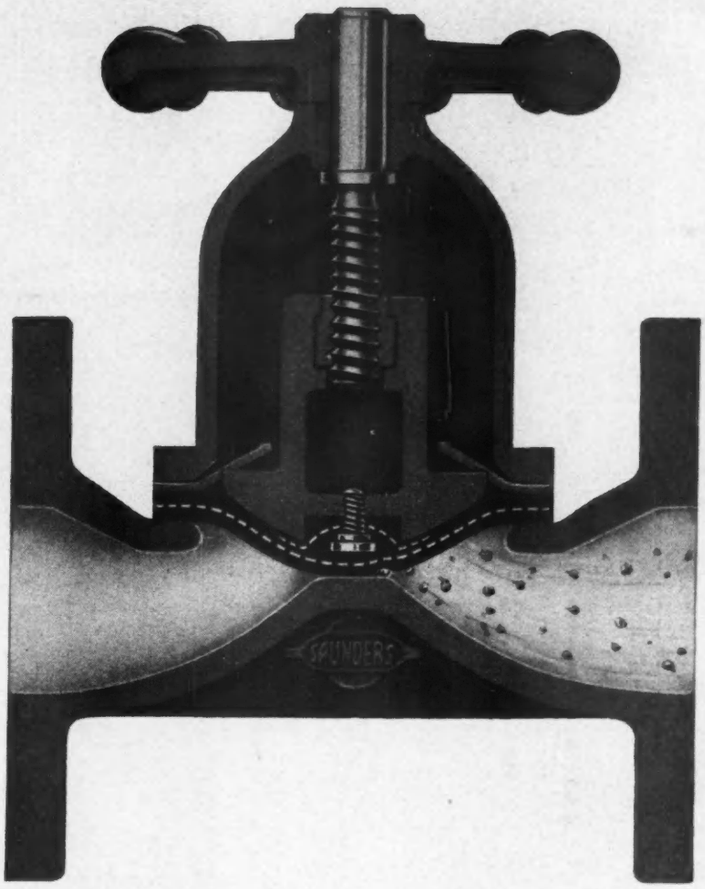

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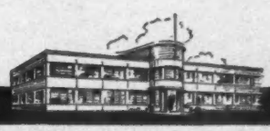

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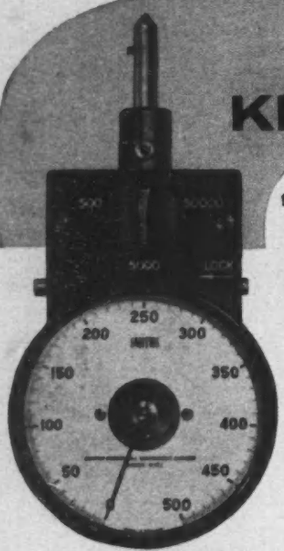

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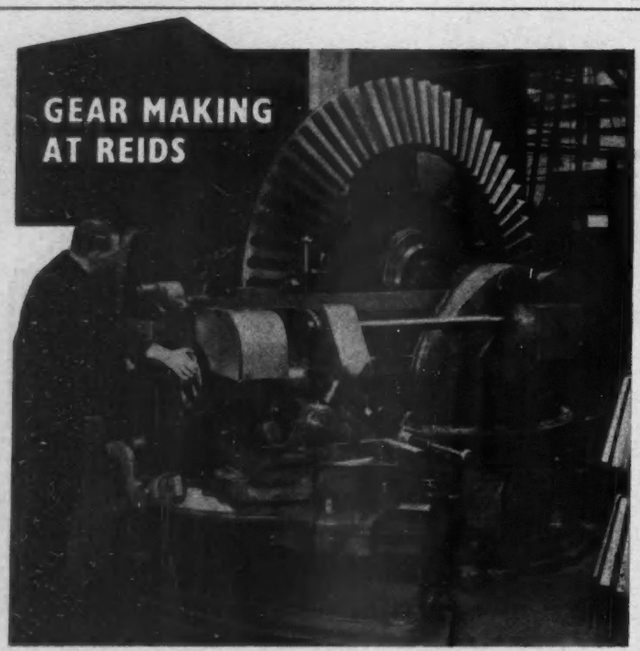

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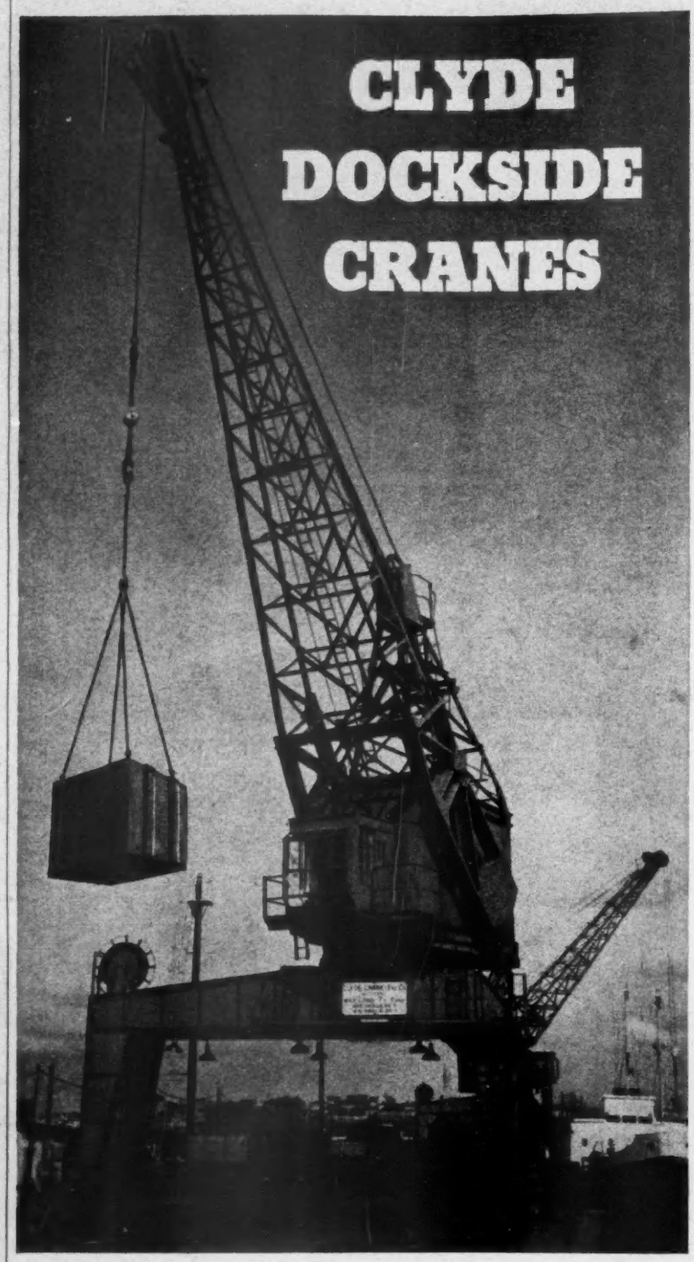

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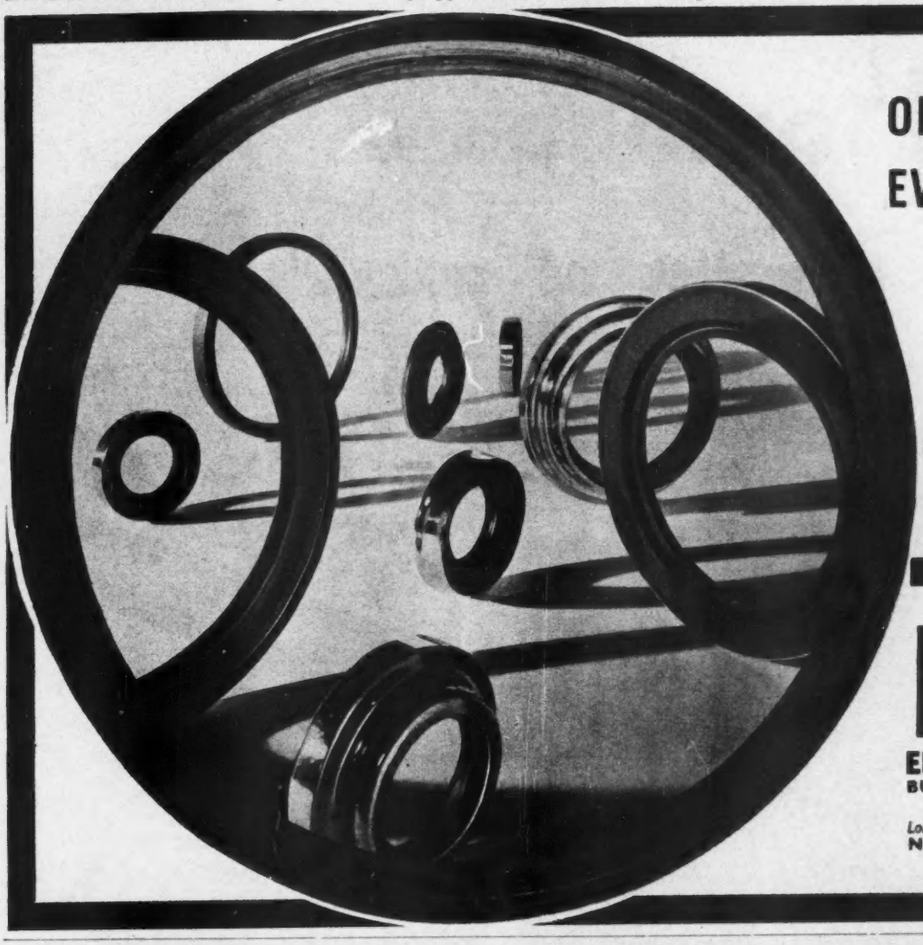

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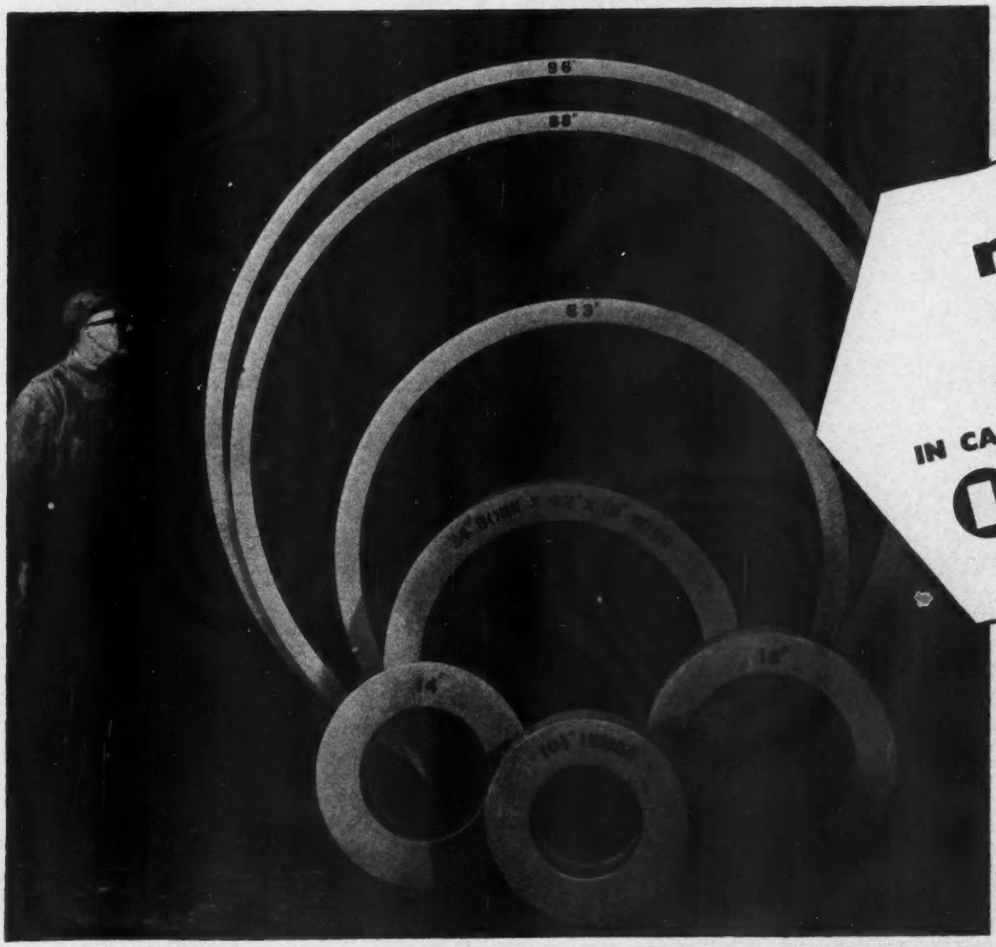

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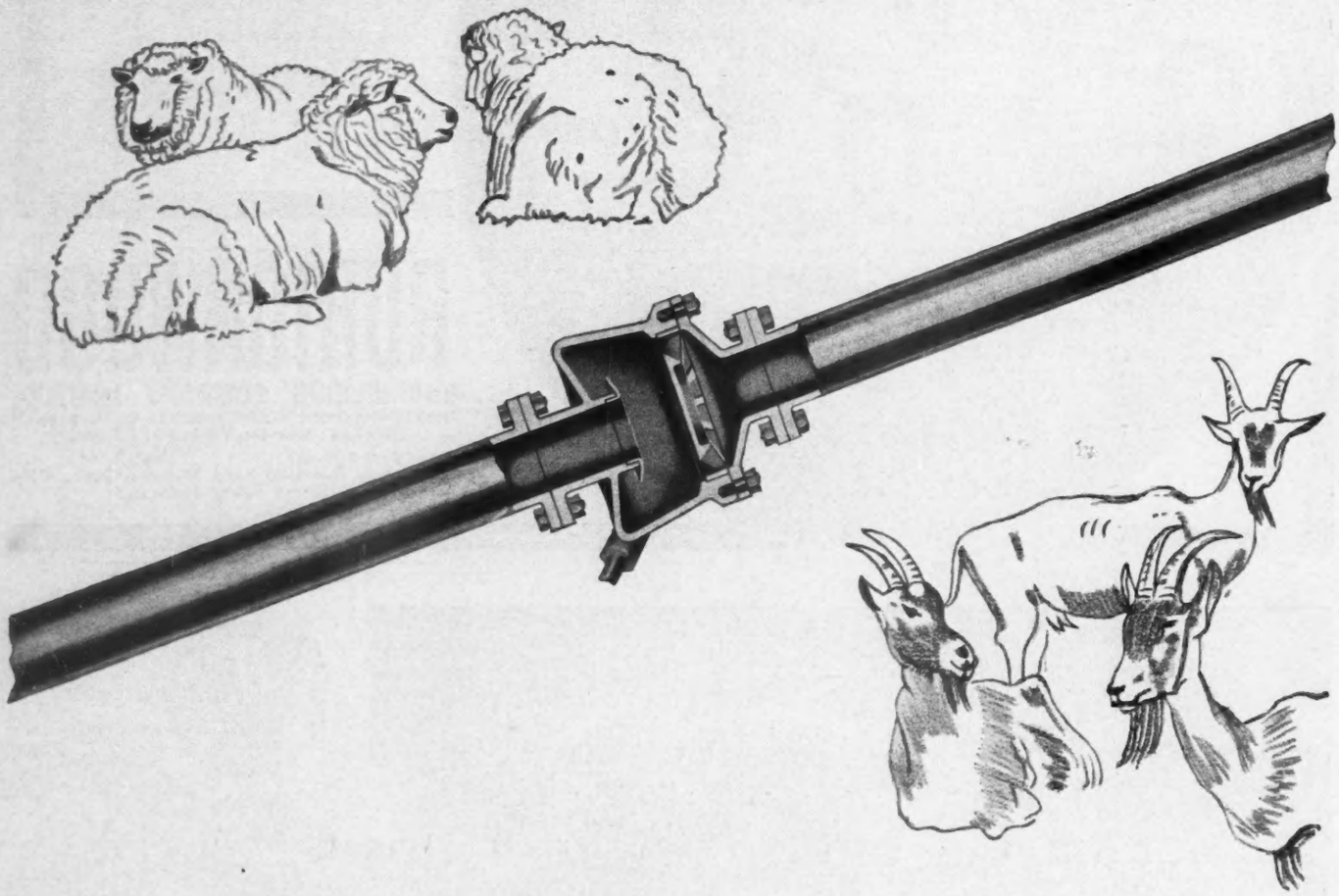

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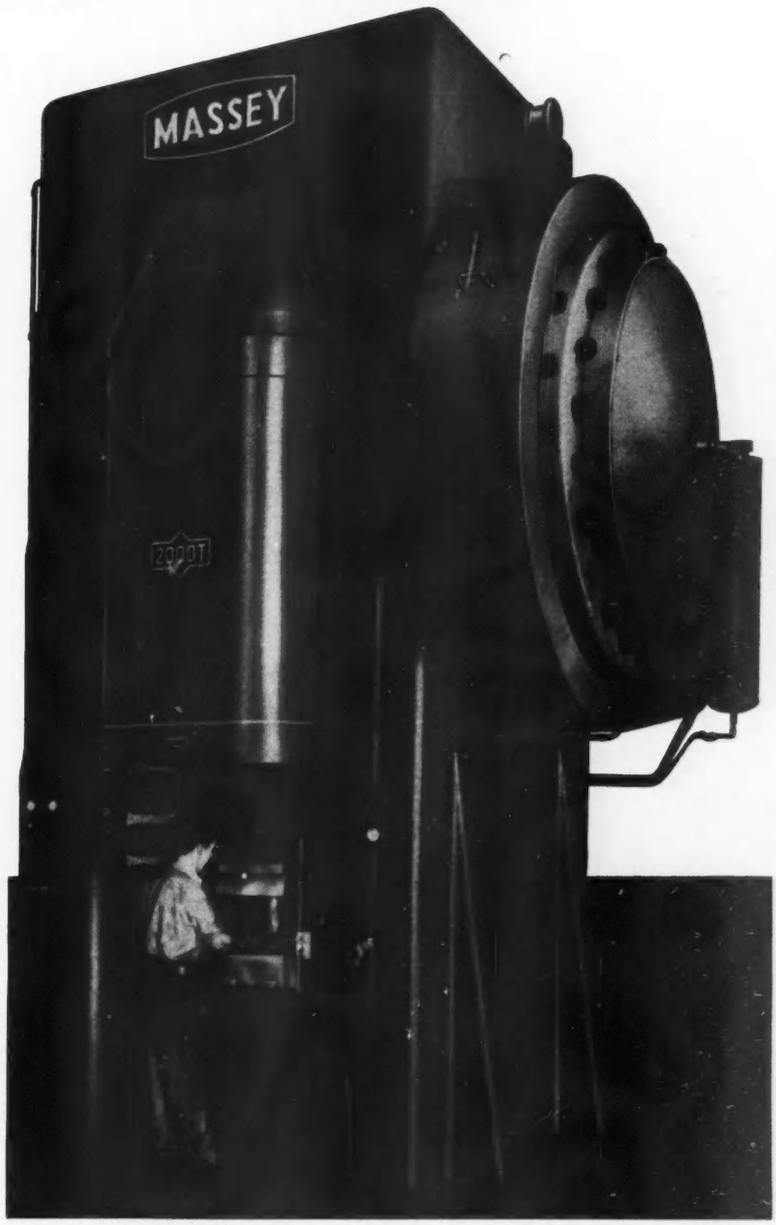

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